SEX DETERMINATION FROM THE SKULL BASED ON FORAMEN MAGNUM MEASUREMENTS - A REGIONAL STUDY IN CHENNAI, TAMILNADU

Dissertation submitted to THE TAMILNADU Dr.M.G.R.MEDICAL UNIVERSITY in partial fulfillment for the award of the degree of

DOCTOR OF MEDICINE IN FORENSIC MEDICINE
Branch XIV

INSTITUTE OF FORENSIC MEDICINE
MADRAS MEDICAL COLLEGE
CHENNAI - 600 003

MARCH - 2009

BONAFIDE CERTIFICATE

This is to certify that this dissertation work entitled **SEX DETERMINATION FROM THE SKULL BASED ON FORAMEN MAGNUM MEASUREMENTS** is the original bonafide work done by Dr.T.Vedanayagam, post graduate student, Institute of Forensic Medicine, Madras Medical College, Chennai under our direct supervision and guidance.

Dean
Government general hospital,
Madras Medical College,
Chennai –600 003.

Director and Professor
Institute of Forensic Medicine,
Madras Medical College,
Chennai –600 003.

ACKNOWLEDGEMENT

I am greatly obliged to the Dean, Dr.T.P.Kalanithi MD, Madras Medical College Government general hospital for allowing me to conduct this study.

I express my profound gratitude to Dr. R. Vallinayagam MD.Director and Professor of Forensic Medicine, Madras Medical College Chennai, for his invaluable guidance for this work.

I most cordially thank Dr. R. Selvakumar MD, Reader in Forensic Medicine Madras Medical College for his constant help and guidance in this study.

I am very much proud to acknowledge my gratitude to Dr. N. Srnivasa Ragavan. MD. , PGDMLE., Dr. V. Sathyamoorthy MD. , Dr. M. N. Rajamani Bheem Rao MD., and Dr. S. Balasubramanian MD., Assistant Professors of Forensic Medicine for their constant encouragement and ideas throughout this study.

I thank all my colleagues for their constant help and support throughout this study. My sincere thanks to the technicians and mortuary attendants for there help in carrying out this study.

CONTENTS

INTRODUCTION

Identification is the determination of the individuality of a person. The question of identification of a living person is mostly the concern of the police and is raised in criminal courts in connection with absconding soldiers, criminals or persons accused of assault, rape, sodomy or murder or when there is mix-up of newborn babies in hospitals or young lost children. It is also raised in civil courts owing to impersonation practiced by people to secure unlawful possession of property or insurance claims (1).

The identification of a living person is based entirely on known-fingerprints or birthmarks or several personal impressions with regard to characteristic gestures movements or shape, features of the teeth, eyes hair or voice.

The identification of a dead body is required in cases of sudden and unexpected death, fires, explosions, railway or aircraft accidents, mutilated or hidden decomposed bodies or foul play often needs great medico-legal acumen. In India, owing to its rapid decomposition in the hot seasons or through damage caused by wild animals, the identification of a dead body sometimes becomes very difficult. However it is essential for a dead body to be thoroughly identified and the proof of **corpus delicti** to be established before a sentence is passed.

The identification of sex from human remains is of fundamental importance in forensic medicine and anthropology, especially in criminal

investigations as well as in the identification of missing persons and in attempts at reconstructing the lives of ancient populations.

The determination of sex is statistically the most important criterion, as it immediately excludes half the population, whereas age, stature and race, each provide within a wide range of variables. The accuracy of determination of the sex of skeletal remains varies with the age of the subject, the degree of fragmentation of the bones and biological variability.(2)

Obvious sex differences do not become apparent until after puberty usually in the 15-18 year period. The accuracy of sexing is hard to estimate, as various loading factors exist. Krogman comments that he scored 100 % accuracy using the whole skeleton,95% on Pelvis,92% on Skull, 98% on Pelvis plus Skull, 80% on long bones, 98% on long bones with Pelvis. Stewart records that for the whole skeleton one can expect a 90-95% success rate and for the skull alone 80%. (3)

Sometimes the process maybe extremely complicated especially when fragmented bones are available.

REVIEW OF LITERATURE

Physical or Biological Anthropology is the field of science that studies man from his earliest beginnings about Five million years ago to the present. The scientific study of the Skeleton of both Human and Animal is found in anthropology.(4) Physical anthropologists have been mainly concerned with the study of the human origins and human evolution as well as the varieties of mankind in different parts of the world. Physical anthropologists have in recent years become increasingly concerned with the dimensions, proportions and shape and the role of man's immediate physical environments.

Forensic Anthropology is the discipline that applies the scientific knowledge of physical anthropology and archaeology to the collection and analysis of legal evidence. Forensic anthropology began as a sub field of physical anthropology but has grown into a distinct body of knowledge, overlapping other fields of anthropology, biology, and the physical sciences.

Recovery, description and identification of human skeletal remains are the standard work of forensic anthropologists. The condition of the evidence varies greatly; including decomposing, burned, cremated, fragmented, or disarticulated remains. Typical cases range from recent homicides to illegal destruction of ancient Indian burials. Forensic anthropologists work on individual cases, mass disasters, historic cases, and international human right cases.

HISTORY OF FORENSIC ANTHROPOLOGY

The public views Forensic anthropology as a young discipline. But it has a long developmental history in the physical anthropologists fascinated by the anatomical collections of museums and universities. Anthropologists were making observations about skeletal differences and writing papers for professional societies decades before any legal application for their knowledge was ever considered. The earliest beginnings of what we call Forensic anthropology can be attributed to a few bright attorneys mired in complicated legal battles. They searched out the knowledge they needed to win and made use of it in court. Little by little, over the last 150 years, anthropologists have responded with goal driven research. Along the way, they learned about the work of law enforcement investigators, the capabilities of other Forensic scientists, and the requirements of a courtroom environment.

There is no date for the beginning of the study of human skeletons, but there is a firm date for the first use of skeletal information in a court of law – the 1850 Webster/Parkman trial. Oliver Wendell Holmes and Jeffries Wyman, two Harvard anatomists, were called to examine human remains thought to be those of a missing physician, Dr. George Parkman. A Harvard chemistry professor, John W. Webster, was accused of the crime of murder. The evidence was substantial even before the anatomists become involved. Webster owed Parkman money; a head had been burned in Webster"s furnace; body parts were found in his lab and privy, and a dentist had identified Parkman's dentures found in the furnace. Holmes and Wyman testified that the remains fit the description of Parkman, and Webster was hanged.(4)

George A. Dorsey, a curator at the Field Museum of Natural History was called to examine a few bits and pieces of bone from the sludge at the bottom of a sausage-rendering vat. Louisa Luetgert, wife of a sausage factory owner, was missing, and her husband, Adolph, was accused of murder. Again, the evidence was substantial even before the anthropologist become involved. Adolph had closed down his plant for several weeks; he had ordered extra potash before closing the plant; he had given the watchman time off on the night of the disappearance; and, most incriminating of all, Louisa's rings were found in the vat. Dorsey had only to prove that the bones were human and he did. Adoph Luetgert was imprisoned for life.

T.Dale Stewart [1901-1997] designated Thomas Dwight [1843-1911] of Harvard University as the "Father of Forensic Anthropology in the United States". This is partially based on the fact that Dwight wrote a prize-winning essay on the subject of identification from the human skeleton in 1878. Dwight may not have been the very first actor in what we now call forensic anthropology, but he was the first to publish.

Early in the twentieth century, many anthropologists contributed to the developing discipline, but Wilton Marion Krogman [1902-1987] was the first to speak directly to law enforcement authorities with his "Guide to the identification of Human Skeletal Material," published by the FBI Law Enforcement Bulletin in 1939. He followed it with "The Role of the Physical Anthropologists in the Identification of Human Skeletal Remains" [1943]. These publications were significant, but not widely read. Most investigators still took any human remains straight to the medical doctor. J. Lawrence Angel

[1915-1986], curator of Physical Anthropology at the Smithsonian Museum says " If they wanted answers, all they had to do was to walk across the street with a box of bones!"

Forensic anthropology may have dawned early in Washington, D.C. but not much was happening in the rest of the country. In the late 1960s William R. Maples, chose The Human Skeleton in Forensic Medicine by Wilton Krogman [1962] as a textbook for a human osteology class.

Forensic anthropology finally began to evolve as a recognizable discipline during the 1970s. T. Dale Stewart edited a Smithsonian publication, titled "Personal Identification in Mass Disasters" [1970]. Next, William M.Bass published the first practical textbook, Human Osteology: A laboratory and Field Manual [1971]. By that time, a few physical anthropologists had begun to attend meetings of the American Academy of Forensic Sciences. In 1972,fourteen people formed a Physical Anthropology section. Soon after, a few adventurous persons started calling themselves "Forensic" anthropologists rather than "Physical" anthropologists. By the end of the 1970s, T. DALE Stewart published Essentials of Forensic Anthropology [1979]- the first textbook to actually carry the name "forensic Anthropology" in its title.

Even in the 1970s forensic anthropology was not an undergraduate subject or even a graduate degree. The forensic anthropologists focused on physical anthropology in graduate school and wrote theses with forensic applications. " Forensic Anthropology" degree titles are a phenomenon of the

late 1980s and 1990s. And the job title " Forensic Anthropologists" is even newer.

Anthropometry

All the human beings occupying this globe belong to the same species i.e. Homo sapiens. (5)No two individuals are exactly alike in all their measurable traits; even genetically identical twins (monozygotic) differ in some respects. These traits tend to undergo change in varying degrees from birth to death, in health and disease. Since skeletal development is influenced by a number of factors producing differences in skeletal proportions between different geographical areas, it is desirable to have some means of giving quantitative expression to variations, which such traits exhibit. Anthropometry constitutes that means, as it is the technique of expressing quantitatively the form of the human body. In other words, anthropometry means the measurement of human beings, whether living or dead or the skeletal material. There are numerous methods of measurement used in biological anthropology.

Forensic medicine is an interdisciplinary science, which in everyday practice applies all the knowledge that medical sciences, have accepted as reliable and scientifically solid facts or processes, and qualitative and quantitative definitions with the help of which accurate and reliable statements can be made.(6) The use of anthropometry in the field of forensic science and medicine dates back to 1882 when Alphonse Bertillon, a French police expert invented a system of criminal identification based on anthropometric measurements. His system was based on three fundamental

ideas, the fixed condition of the bone system from the age of twenty till death; the extreme diversity of dimensions present in the skeleton of one individual compared to those in another; the ease and relative precision with which certain dimensions of the bone structure of a living person can be measured using simply constructed calipers. This system of identification spread rapidly through much of the world but the system was not accepted much in view of some major drawbacks and discovery of other identification systems e.g. dactylography. (7)

As anthropometry is an important part of biological/physical anthropology, the persons specializing in anthropometry are familiar with range of biological variability present in the human populations and its causes, and are well trained in comparative osteology, human osteology, craniometry, osteometry, racial morphology, skeletal anatomy and function. They are well aware of the knowledge of archaeological field techniques and methods which serve well in crime scene recoveries involving buried and surface remains.(8) The term ‘forensic anthropometry' can be coined for this branch of applied physical anthropology, involving the use of methods/techniques of anthropometry in forensic/legal context. In other words, “forensic anthropometry is a scientific specialization emerged from the discipline of forensic anthropology dealing with identification of human remains with the help of metric techniques”.

Anthropometric characteristics have direct relationship with sex; shape and form of an individual and these factors are intimately linked with each other and are manifestation of the internal structure and tissue components,

which in turn, are influenced by environmental and genetic factors. Anthropometric data are believed to be objective and they allow the forensic examiner to go beyond subjective assessments such as ‘similar' or ‘different'. With measurement data, the examiner is able to quantify the degree of difference or similarity and state how much confidence can be placed in this interpretation. (9)

The main aim of an anthropometrist employed in the forensic medicine/medico-legal department, working with unknown variables, is to describe the remains in such terms so that one can achieve the goal of estimating age at the time of death, sex, stock/race/ancestry/ethnicity, stature, body weight/body build, details of individualizing characteristics i.e. amputations, fractures, ankyloses, deformities and bone pathologies and to some extent the cause of death if reflected in the remains/bones. The objective is to enable the law enforcement agencies to achieve the ultimate goal of personal identification.

Krogman in his monumental publication (later on revised with Iscan)“The Human Skeleton in Forensic Medicine” describes that the use of anthropometry may arise under several sets of circumstances i.e. Natural, intentional and accidental (war dead cases, air crash, road and train accidents, earth quake, flood, fire; deliberately mutilation, disfigurement, pounding, gouging etc. of the dead body). (10,11)

Forensic anthropometry incorporates most of the techniques originating with the analysis of human skeletal material from archaeological sites; the two

disciplines have been closely linked. A good forensic anthropologist must, by definition, be a good skeletal biologist.(12) Forensic anthropologist helps a forensic pathologist to reconstruct the biological nature of the individual at the time of postmortem examination, and sometimes giving clues and reconstructing the circumstances surrounding death. Forensic anthropologist is prepared for this by his training in describing the prehistoric skeletons from archaeological sites and usually by special experience in identifying unknown modern skeletons.(13)

Anthropometry can be subdivided into Somatometry and Osteometry

Somatometry

It is the measurement of the living body and cadaver including head and face. Somatometry is considered as a major tool in the study of human biological variability including morphological variation. Studies of morphological variation, by their very nature have a comparative focus in which variation within and among populations is the central theme.

Osteometry

Osteometry includes the measurements of the skeleton and its parts i.e. the measurements of the bones including skull. Through this technique, a forensic scientist can study variation in bony skeleton of different populations of the world. The technique has been successfully used in the estimation of stature, age, sex and race in forensic and legal sciences. These four parameters i.e. age, sex, race and stature is considered as the “Big Fours” of forensic

anthropology. Various studies have been conducted and are in progress in many parts of the world in this regard.

Estimation of stature

In the past, scientists have used each and every bone of the human skeleton right from femur to metacarpals in estimation of stature. They all have reached a common conclusion that stature can be estimated with great accuracy even from the smallest bone, although, they have encountered a small error of estimate in their studies. Some authors have used fragments of the long bones i.e. upper or lower end etc. but most of the time, long bones have been used in the determination of stature because they relatively give better accuracy in prediction of stature. There are various ways to estimate stature from bones but the easiest and the reliable method is by regression analysis.(13,14,15)

Estimation of Age

Skeletal age can be determined from the ossification of bones. The human bones develop from a number of ossification centers.3. At 11-12th week of intrauterine life there are 806 ossification centers that at birth reduced to about 450. Adult human is made up of 206 bones. The time of appearance of center of ossification and the process of union of the epiphysis with the diaphysis at the metaphysis have a sequence and time that is utilized towards determination of age. Ossification centers are studied up to the age of 20-22 years, thereafter the skull vault sutures, union and activity of sternum, changes in shape of mandible and changes in pubic symphysis are taken in to account. In the skull absence of any signs of closure of any suture, points to the strong

possibility of the age having not exceeded thirty years. The sutural closures occur earlier in males than females

Determination of Race (16,17,18,19,20)

For the determination of race, three primary racial distributions are recognized for the whole population of the world. They are 1) Caucasians,2) Mongolians 3) Negroes.

Caucasians have thin, fair skin; blue or gray iris; thin, straight or wavy, fair or light brown or reddish scalp hair; raised forehead; narrow nasal aperture; mostly roundish, mesocephalic index being between 75 to 80.

Mongolians have yellowish or pale skin; black iris; black and straight or wavy hair; inclined forehead; higher, roundish orbit; large, flattened face; small upper and lower extremities and a square, short brachy cephalic head with a cephalic index being between 80 to 85.

Negroes have black, tough skin; black iris; black, curly or wooly scalp hair; small and compressed forehead; lower and wider orbit; broad and wider nasal aperture; prominent molar bones; oblique teeth; proportionately longer forearm than arm; narrow, dolico cephalic skull with cephalic index varying between 70 to 75.

Determination of race is not so simple. In spite of several multivariate statistical studies of specific measurements of the skull and a few long bones, this is still one of the most problematic in skeletal identification. Race determination is further complicated by another major factor i.e. one may

encounter intrinsic variability within each major genetic breeding population or endogamous group.

Determination of sex

In medico-legal cases, bones form important evidence in establishing sex of the deceased. The bones provide clues regarding race, age, stature and sex of an individual. Sex of an individual can be identified accurately in 90% of the cases using pelvis alone, 80% of cases using skull alone and in 98% cases using pelvis and skull together.(3)

Sexing of the skull is predominantly done using non -metrical parameters, which are at best appropriate only in relative terms.

The sexual difference in the human skeleton has been well studied in many populations. The skeletal components most often investigated for gender determination are the pelvis and the skull. Identification of humans using the unique features of teeth and jaws has been used since Roman times, because humans show dimorphism in jaw and teeth dimensions and morphology of both adults and children. One of the important aspects of forensics is to determine sex from fragmented jaws and dentition. Sometimes the diagnostic procedure may be extremely complicated when fragmented bones are handled. When only skulls or fragmented jaws are available for sex determination, forensic experts may use methods that are based on the measurement of various bone parameters and analysis of cranial osteological traits like shape of the glabella, size of the mastoid process, orbital form, frontal profile, shape of the occipital protuberance or size of the foramen magnum. Identification of sex is made on

differences in shape and size of the morphological marks. The morphological marks are more subjective and sex determination depends on experience of the investigator, so visual methods of sexing skull are likely to be inaccurate when performed by an inexperienced worker. In sexing a skull the initial impression is often the deciding factor; a large and robust skull is generally male, a small and gracile skull is female. This subjective approach of sexing skull may sometimes produce misleading results. Methods based on measurements and morphometry are accurate and can be used in determination of sex from the skull. Discriminant function analysis of skeletal measurements is a reliable method that overcomes some of the problems inherent in subjective methods of sexing skulls. It is increasingly utilized for sex diagnosis from skeletal measurements.(21).

The female bones are usually smaller, thinner and lighter than bones of the males in adults whose bones are thicker and massive. The bones in case of males have more prominent ridges and the processes are more marked compared to females. Also in males the shafts of bones have coarser surface and articular surfaces are wider compared to females where the shaft of long bones are smooth and articular surfaces are smooth and round. The male skeleton weighs about 4.5kg while it is 2.5kg in females. While determining the sex from the bones the percentage of accuracy from independent skeletal part (as given by Krogman 1964) is (3)

(i) Whole skeleton (100%)

(ii) Pelvis and skull (98%)

(iii) Pelvis alone (95%)

(iv) Skull alone (92%)

(v) Skull and long bones (96%)

(vi) Pelvis and long bones (98%)

(vii) Long bones alone (80-85%).

Sex was correctly estimated by the experienced anthropologist in 100% of individuals using all of the 16 pelvic and cranial criteria. In fact, sex differences in pelvic morphology were large enough to allow sexing the individuals with 100% accuracy. Among seven features observed on the pelvic bones, the least reliable single sex indicator was the width of the great sciatic notch (with accuracy of 79.15%). Looking at the skull alone, sex was correctly determined in 70.56% cases. It was shown that the most accurate single indicators among cranial methods was the robustness of the mandible (with accuracy of 70.93%), while the sharpness of the supraorbital margins was the least reliable indicator demonstrating accuracy in only 28.75% of crania. Examination of the sample by an individual with training in physical anthropology, but no case experience, suggests that experience is likely to contribute moderately to the accuracy of the sex determination. Namely, the inexperienced anthropologist accurately assessed the sex of the sample 95.04% of the time; 4.06% less accurate than the experienced anthropologist. The two anthropologists showed the least agreement in scoring the ventral arc and composite arc on the pelvic bones.

Pelvis alone is sufficient for determination of sex especially in adults in more than 90% of cases. In case of children and fetus even from the examination of the pelvis sex can be determined with fair accuracy. Even in

adolescents' greater sciatic notch is the single most important criteria from which sex can be determined. The pelvis affords the best marked most reliable characteristics for distinguishing sex in over ninety percent of the subjects. The female pelvis is shallower, wider, smoother and less massive than the male pelvis. The ilia in the female are less sloped, their posterior borders are more rounded, the anterior superior iliac spines are more widely separated and the great sciatic notches are much wider, forming almost a right angle than in the male.

Patriquin et al designed nine measurements of pelvis and analyzed sex differences in South African white and black population. They made use of stepwise discriminant function analysis and presented anthropometric standards of the pelvis of South African white and blacks.(22) They further concluded that the ischial length is the most sexually dimorphic dimension in whites (averaged accuracy 86%) and acetabulum diameter is the most diagnostic in blacks (averaged accuracy 84%).

The female sacrum is short and wide, and is sharply curved forward in its lower half, while the male sacrum is long and narrow, has a uniform curvature along its whole length, and may have more than five segments. The auricular surfaces extend over two to two-and-a-half stunted bodies in females, and over two-and-a-half to three elongated bodies in males. The obturator foramina are triangular in females and ovoid in males. The pre-auricular sulci are commonly present and well marked in the multiparous female. The superior aperture of the lesser pelvis in females is larger, more nearly circular, and its obliquity is greater than in males. The ischial tuberosities are everted in

females, and are inverted in males. The acetabula are narrow in females and wider in males. The pubic symphysis in females is less deep, and the pubic arch is wider and more rounded than in males, where it forms an angle rather than an arch. After puberty in females, the dorsal border of the pubic symphisis is irregular and shows marks of parturition in the form of depressions or pits caused by traumatisation during child bearing.

Rissech et al analyzed four variables of the ischium by polynomial regression in order to determine sex during and after growth.(23) They calculated growth curves for ischium length, horizontal diameter of ischium acetabular surface, vertical diameter of ischium acetabular surface and ischium acetabular index and concluded that the ischium length is the best variable for determination of sex in west European collections. Rissech and Malgosa used coxal bones of 327 individuals taken from four documented skeletal series i.e. The St. Bride's Collection, London; Esqueletons identificados, Coimbra;(24) The Lisbon Collection, Lisbon; and UAB Collection, Barcelona in sex determination. The measurements include ileum width, ileum length, ileum index, horizontal diameter of the ileum acetabular area and vertical diameter of the ileum acetabular area and they concluded that the ileum width is the best variable fore sex determination.

The determination of sex by femur is of considerable importance. The neck of the femur forms almost a right angle with its shaft in females, and an obtuse angle in males, while the head of the femur in males forms about two-thirds of a sphere, and is larger than that of the femur in females. The femur in males is a little more inclined than in females. Trancho et al made use of 132

femora of adult Spanish population for determination of sex by discriminant function analysis.(25) They measured femur for five anthropometric variables and achieved between 84% to 97% accuracy when each variable was considered independently. 99% accuracy was obtained when two variables of the epiphysis were combined. Asala used femur head to determine sex in South African whites and blacks from Raymond Dart collection. (26) He took two variables i.e. vertical femoral head diameter and transverse femoral head diameter and concluded that these can be used successfully for sex determination in absence of complete bone. He further concluded that the sex from this bone must be calculated separately for each population. Purkait conducted a study on 280 femora from central India. (27) She used the points of traction epiphysis on the upper end of the femur and the triangle was drawn on the posterior aspect of the femur using the apex of two traction epiphysis and the lateral most point on the articular margin of the head. Each length of the triangle was analyzed. She observed that all dimensions were greater in females. The accuracy rate ranged from as little as 63% for the distance between the point on the femoral head and the greater trochanter to 85% for the distance between the greater and lesser trochanters.

Iscan et al used seven anthropometric parameters of tibia including tibial length, diameters and circumferences for determination of sex from 84 Japanese skeletons.(28) They used multiple combinations of measurements to develop formulae for determination of sex and the average prediction accuracy ranged from 80% to 89%. They further conclude that the accuracy of prediction was higher in males (96%) than females (79%). Slaus and Tomicic used 180

tibiae from six medieval archaeological sites in Croatia in sex determination.(29) They measured six anthropometric dimensions on tibia and showed that complete tibiae can be sexed with 92.2% accuracy.

The female thorax is shorter and wider than that of the male. The sternum in females is shorter, and its upper margin is on a level with lower part of the body of the third thoracic (dorsal) vertebra. In the male, it is on a level with lower of the body of the second. The sternal body is less than twice the length of the manubrium in the female, while it is more than twice its length in the male. This is due to the fact that the manubrium in the male is somewhat smaller than that in the female. The ribs are thinner and have a greater curvature, and the costal arches are larger in females. Frutos measured maximum length and circumference of the mid shaft of the clavicle and height and width of the glenoid fossa of the scapula for sex determination in Gautemalan contemporary rural indigenous population.(30) They made use of jackknife method (leave-one-out method) and it produced classification success rates ranging from 85.6% to 94.8%.

Frutos conducted a study based on 118 complete humeri from Guatemalan forensic sample.(31) He studied six anthropometric dimensions and concluded that the classification accuracies for the univariate functions range from 76.8% to 95.5% and for stepwise function procedure was 98.2%.

Kemkes-Grottenthale evaluated the reliability of patella anthropometry in sex determination in a material from different archaeological samples. He achieved almost 84% accuracy in sex determination.(32)

Mall et al measured various anthropometric dimensions of humerus, ulna and radius to determine sex by using discriminant analysis.(33) They concluded that radius (94.93%) is the best bone for sex determination, followed by humerus (93.15%) and ulna (90.58%).

Falsetti made assessment of sex from dimensions of metacarpal in three samples i.e. The Terry collection, sample from Royal Free Medical School, forensic collection of Maxwell Museum of Anthropology, University of New Mexico.(34) He designed five measurements for the metacarpal and found different accuracy rates in different samples.

Smith utilized metatarsals, proximal pedal phalanges and the first distal phalanx of the foot in determination of sex from The Terry and Huntington Collections of the Smithsonian Museum of the Natural History.(35) The anthropometric measurements include lengths and medio-lateral and dorso-plantar widths of these foot bones. He recommended the use of combination models for correct assignment of sex as he achieved 87% accuracy with this model.

An investigation by Bidmos and Dayal is based upon anthropometric study of 60 male and 60 female tali of South African white from Raymond Dart collection.(36) They concluded that by using discriminant analysis, the level of average accuracy of sex classification was 80% to 82% for the univariate method, 85% to 88% for the stepwise method, and 81% to 86% for the direct method.

Discriminant function analysis is suitable for this purpose because it is primarily used to classify individuals into two (males and females) or more uniquely defined populations. To develop a discriminant rule for classifying individuals into one of several possible categories, the researcher must have a random sample of individuals from each possible classification group. Discriminant analysis provides methods that will allow researchers to build rules that can be used to classify other experimental units into one of the classification groups.

Numerous studies have clearly demonstrated that skeletal characteristics vary by population and that there is a need for population specific standards for sex determination (8). The present study is an attempt to derive a discriminant function to determine sex of skeletal remains from two Croatian archeological sites using 18 mandible measurements.

Patil and Mody conducted a lateral cephalometric study on central Indian population to devise a model for determination of sex.(37) They took ten measurements on the radiographic cephalograms of 150 normal healthy individuals and determined sex by discriminant function analysis. They concluded that the variables provided 99% reliability in sex determination.

Practical implications and reliability in anthropometry

Precision in anthropometry is of utmost importance, as it requires lot of practice. Reliability of the measurement should be established and the best order for recording the measurements selected for a particular study or a particular problem should be determined. The most common errors in

anthropometry are positioning of the body or bones, reading measurements and recording. In other words, these errors are also termed as personal error and technical error of measurement respectively. In order to minimize these errors, standard procedures for recording these measurements should be used which are internationally recognized.

General Characters of Skull

The skull is broadly composed of two types of bones; cranial and facial. Cranial bones enclose a single cavity that surrounds the brain, while the facial bones form a number of smaller cavities around the sense organs. The cranial cavity is dome shaped with a smooth convex roof [cranial vault] and an uneven floor [cranial base] The base is divided in to three regions- anterior, middle and posterior cranial fossae- that lie at progressively lower levels from front to back. The ventral surface of the brain lies against this base, which consequently contains a number of foraminae for exiting vascular structures. The facial skeleton is suspended below the anterior and middle cranial fossae, the upper end of the gut tube being attached to the back of the facial skeleton anteriorly and suspended from the middle fossa posteriorly, while below the posterior fossa lies the supporting vertebrae with their cavity –the vertebral canal- for the spinal cord.(2)

Study of the skull as a whole, and even of its individual bones, is best undertaken by viewing it from standard positions called " Norma". These are the normae frontalis, lateralis, verticalis and basalis. The skull is placed in a standard reference position with a line connecting the inferior orbital margin to

the upper aspect of the external auditory meatus set in the horizontal plane the so called “Fronkfort plane”. Of these views, the norma frontalis, lateralis and verticalis provide most of the salient information for craniofacial reconstruction, however, distinctive features of both the norma basalis and norma occipitalis may influence the final result.

Norma frontalis view illustrates aspects of all three cavities of the face as well as the larger facial bones. Mandible is the separate bone that articulates via its condylar head with the squamous temporal bone of the cranial base. The mandible is often used to sex skeletal remains, and several measures may be taken on the bone For example, the bicondylar breath, the direct transverse distance between the most lateral points on the two condyles, is usually greater in males. The mandible in the male is more robust larger and thicker than in the females, with greater body height, especially at the protuberance, and a broader ascending ramus. The gonial angle is less obtuse, the condyles are larger and the chin is square, in contrast it being V-shaped in females.

The bones comprising the frontal view are generally smaller in the female, with smoother and less pronounced landmarks. Features that distinguish the sexes include the contour of the forehead, which, due to a more prominent frontal tuber, is higher and more vertical in the female than in the male; the supercillary arches are much less strongly developed than in the male, the orbits are higher, more rounded and relatively larger compared with the upper facial skeleton, and the orbital margins sharper and less rounded than in the male. In the male, the nasal aperture is higher and narrower, and its

margins are sharp rather than rounded. The male nasal bones are also larger and tend to meet in the midline at a sharper angle.

Norma Occipitalis

The occipital view of the skull provides little information for craniofacial reconstruction that has not already been deciphered from the frontal and lateral aspects. The external occipital protuberance is much larger in the male, as are the occipital condyles, and the transverse occipital lines are more evident. At the opisthocranion, a position just above the external occipital protuberance, the skull attains its greatest posterior extent.

Norma Basalis

This inferior view of the skull is complex, displaying features of both frontal bones and of the cranial base, with its numerous foraminae for neuro - vascular structures. It is divided into three zones. The anterior zone comprises the hard palate and the upper dentition, i.e. the inferior view of the frontal bones as they attach to the cranial base. The posterior zone is located behind a transverse line drawn tangential to the anterior margin of the foramen magnum, that is, those features to which structures of the neck attach. Mainly the base of the sphenoid, the petrous processes of the temporal bone and the basilar part of the occipital bone in between occupy the intermediate zone.

The most important of parameters to determine from a skeleton is the sex of an individual. If a bone is successfully sexed, approximately 50% of the population is immediately eliminated from the process of identification. Sex –

distinguishing characteristics of the skeleton are based on the differences that arise in males and females as a consequence of sexual maturation. Sex determination may be made from the cranium or from bones of the postcranial skeleton, although, in general, evaluation of the pelvis and the modifications that occur to permit childbirth provides a more reliable estimate of sex than do cranial measurements. While sexual differences begin to develop in the skeleton before birth, it is not until the individual approaches the age of about 16-18 years that decisions on sex difference can be made with any confidence. Because sex differences are unique to a given race, if it is possible to establish racial affinity, this should be done first before attempting to document sex.

Sex determination from the cranium and mandible relates to their relative size and robustness, so it is necessary to take into account the specific sexual dimorphism of the racial group to which the skull belongs.

Sex Determination by Morphological Characteristics of the Cranium

As the majority of sex-distinguishing features do not become pronounced until puberty, they are most appropriate for sex determination within the age range 20-55 years (Krogman and Iscan, 1986), before the onset of senile changes. Male and female skulls may be distinguished by a number of characteristics.

In general, the female skull shows a rounded appearance, ‘tending to retain more the adolescent form’ (Brothwell, 1981). The male skull tends to be larger and heavier (up to 200 cubic centimeter more cranial capacity) than the female, and it is more rugged, with prominent landmarks for muscular and

ligamentous attachments. The male supraorbital ridges are better defined and the frontal sinuses larger. The mastoid and styloid processes, and external occipital protuberance, are well developed in the male, whereas parietal and frontal eminences are not prominent. The upper margin of the orbit in the male is more rounded (in the female, it is sharper), and the cheekbones are heavier. The male palate is large and broad, and the posterior root of the zygomatic process extends beyond the external auditory meatus for some distance as a clearly defined ridge. The male mandible is more robust, with a U- shaped chin, broad ramus and flared gonial regions. When an entire skeleton is available for inspection, sex-determination is usually immediately possible with 95-100% accuracy. Accuracy of prediction decreases to approximately 95% with the pelvis alone, 90% with the skull alone and 80-90% with the bones of the postcranial skeleton. (21)

FEATURES	MALE	FEMALE
General Size	Large	Small
Architecture	Rugged	Rugged
Supraorbital Ridges	Smooth	Small To Medium
Mastoid Processes	Medium To Large	Small To Medium
Occipital Region	Marked Muscle Lines And Attachments	Not Marked Muscle Lines And Attachments
Frontal Eminences	Small	Large
Parietal Eminences	Small	Large
Orbits	Square With Round Margins	Round With Sharp Margins
Forehead	Sloping-Less Rounded	Vertical
Cheekbones	Heavier, Laterally Arched	Light, Compressed
Palate	Large, Broad, U-Shaped	Small, Parabolic
Occipital Condyles	Large	Small
Mandible	Large, High Symphysis, Broad Ramus	Small, Lower Symphysis And Smaller Ramus
Chin Shape	U-Shaped	V-Shaped
Gonial Angle	Angled	Vertical
Gonial Flare	Pronounced	Slight

Ossa Cranii & Os Occipitale (36,37)

The occipital bone, situated at the back and lower part of the cranium, is trapezoid in shape and curved on itself. A large oval aperture, the foramen magnum, through which the cranial cavity communicates with the vertebral canal, pierces it.

The curved, expanded plate behind the foramen magnum is named the squama**;** the thick, somewhat quadrilateral piece in front of the foramen is called the basilar part**,** whilst on either side of the foramen is the lateral portion**.**

Squama occipitalis. **—**The squama, situated above and behind the foramen magnum, is curved from above downward and from side to side.

Surfaces —The external surface is convex and presents midway between the summit of the bone and the foramen magnum a prominence, the external occipital protuberance**.** Extending lateral ward from this on either side are two curved lines, one a little above the other. The upper, often faintly marked, is named the highest nuchal line**,** and to it the galea aponeurotica is attached. The lower is termed the superior nuchal line**.** That part of the squama, which lies above the highest nuchal lines, is named the planum occipitale**,** and is covered by the Occipitalis muscle; that below, termed the planum nuchale**,** is rough and irregular for the attachment of several muscles. From the external occipital protuberance a ridge or crest, the median nuchal line**,** often faintly marked, descends to the foramen magnum, and affords attachment to the ligamentum nuchæ; running from the middle of this line across either half of the nuchal plane is the inferior nuchal line**.** Several muscles are attached to the outer

surface of the squama, thus: the superior nuchal line gives origin to the Occipitalis and Trapezius, and insertion to the Sternocleidomastoideus and Splenius capitis: into the surface between the superior and inferior nuchal lines the Semispinalis capitis and the Obliquus capitis superior are inserted, while the inferior nuchal line and the area below it receive the insertions of the Recti capitis posteriors major and minor. The posterior atlantoöccipital membrane is attached around the postero-lateral part of the foramen magnum, just outside the margin of the foramen.

The internal surface is deeply concave and divided into four fossae by a cruciate eminence**.** The upper two fossæ are triangular and lodge the occipital lobes of the cerebrum; the lower two are quadrilateral and accommodate the hemispheres of the cerebellum. At the point of intersection of the four divisions of the cruciate eminence is the internal occipital protuberance**.** From this protuberance the upper division of the cruciate eminence runs to the superior angle of the bone, and on one side of it (generally the right) is a deep groove, the sagittal sulcus**,** which lodges the hinder part of the superior sagittal sinus; to the margins of this sulcus the falx cerebri is attached. The lower division of the cruciate eminence is prominent, and is named the internal occipital crest**;** it bifurcates near the foramen magnum and gives attachment to the falx cerebelli; in the attached margin of this falx is the occipital sinus, which is sometimes duplicated. In the upper part of the internal occipital crest, a small depression is sometimes distinguishable; it is termed the vermian fossa since it is occupied by part of the vermin of the cerebellum. Transverse grooves, one on either side, extend from the internal occipital protuberance to the lateral angles of the bone;

those grooves accommodate the transverse sinuses, and their prominent margins give attachment to the tentorium cerebelli. The groove on the right side is usually larger than that on the left, and is continuous with that for the superior sagittal sinus. Exceptions to this condition are, however, not infrequent; the left may be larger than the right or the two may be almost equal in size. The angle of union of the superior sagittal and transverse sinuses is named the confluence of the sinuses (torcular Herophili), and its position is indicated by a depression situated on one or other side of the protuberance.

Lateral Parts (pars lateralis). —The lateral parts are situated at the sides of the foramen magnum; on their under surfaces are the condyles for articulation with the superior facets of the atlas. The condyles are oval or reniform in shape, and their anterior extremities, directed forward and medial ward, are closer together than their posterior, and encroach on the basilar portion of the bone; the posterior extremities extend back to the level of the middle of the foramen magnum. The articular surfaces of the condyles are convex from before backward and from side to side, and look downward and lateral ward. To their margins are attached the capsules of the atlantoöccipital articulations, and on the medial side of each is a rough impression or tubercle for the alar ligament. At the base of either condyle the bone is tunneled by a short canal, the hypoglossal canal (anterior condyloid foramen). This begins on the cranial surface of the bone immediately above the foramen magnum, and is directed lateral ward and forward above the condyle. It may be partially or completely divided into two by a spicule of bone; it gives exit to the hypoglossal or twelfth cerebral nerve, and entrance to a meningeal branch of

the ascending pharyngeal artery. Behind either condyle is a depression, the condyloid fossa**,** which receives the posterior margin of the superior facet of the atlas when the head is bent backward; the floor of this fossa is sometimes perforated by the condyloid canal**,** through which an emissary vein passes from the transverse sinus. Extending lateral ward from the posterior half of the condyle is a quadrilateral plate of bone, the jugular process**,** excavated in front by the jugular notch**,** which, in the articulated skull, forms the posterior part of the jugular foramen. The jugular notch may be divided into two by a bony spicule, the intrajugular process**,** which projects lateral ward above the hypoglossal canal. The under surface of the jugular process is rough, and gives attachment to the Rectus capitis lateralis muscle and the lateral atlantoöccipital ligament; from this surface an eminence, the Para mastoid process**,** sometimes projects downward, and may be of sufficient length to reach, and articulate with, the transverse process of the atlas. Laterally the jugular process presents a rough quadrilateral or triangular area, which is joined to the jugular surface of the temporal bone by a plate of cartilage; after the age of twenty-five this plate tends to ossify.

The upper surface of the lateral part presents an oval eminence, the jugular tubercle**,** which overlies the hypoglossal canal and is sometimes crossed by an oblique groove for the glossopharyngeal, vagus, and accessory nerves. On the upper surface of the jugular process is a deep groove, which curves medial ward and forward and is continuous with the jugular notch. This groove lodges the terminal part of the transverse sinus, and opening into it, close to its medial margin, is the orifice of the condyloid canal.

Basilar Part **(**pars basilaris**).** —The basilar part extends forward and upward from the foramen magnum, and presents *in front* an area more or less quadrilateral in outline. In the young skull this area is rough and uneven, and is joined to the body of the sphenoid by a plate of cartilage. By the twenty-fifth year this cartilaginous plate is ossified, and the occipital and sphenoid form a continuous bone.

Surfaces —On its lower surface**,** about 1 cm. in front of the foramen magnum is the pharyngeal tubercle, which gives attachment to the fibrous raphé of the pharynx. On either side of the middle line the Longus capitis and Rectus capitis anterior are inserted, and immediately in front of the foramen magnum the anterior atlantoöccipital membrane is attached.

The upper surface presents a broad, shallow groove, which inclines upward and forward from the foramen magnum; it supports the medulla oblongata, and near the margin of the foramen magnum gives attachment to the membrana tectoria. On the lateral margins of this surface are faint grooves for the inferior petrosal sinuses.

Angles —The superior angle of the occipital bone articulates with the occipital angles of the parietal bones and, in the fetal skull, corresponds in position with the posterior fontanelle**.** The inferior angle is fused with the body of the sphenoid. The lateral angles are situated at the extremities of the grooves for the transverse sinuses: each is received into the interval between the mastoid angle of the parietal and the mastoid part of the temporal.

Borders —The superior borders extend from the superior to the lateral angles: they are deeply serrated for articulation with the occipital borders of the parietals, and form by this union the lambdoidal suture**.** The inferior borders extend from the lateral angles to the inferior angle; the upper half of each articulates with the mastoid portion of the corresponding temporal, the lower half with the petrous part of the same bone. The jugular process, the notch on the anterior surface of which forms the posterior part of the jugular foramen, separates these two portions of the inferior border from one another

Structure. —The occipital, like the other cranial the outer and inner tables, between which is the cancellous tissue or dipole; the bone is especially thick at the ridges, protuberances, condyles, and anterior part of the basilar part; in the inferior fossæ it is thin, semitransparent, and destitute of dipole.

Ossification —The planum occipitale of the squama is developed in membrane, and may remain separate throughout life when it constitutes the *interparietal* bone; the rest of the bone is developed in cartilage. The number of nuclei for the planum occipitale is usually given as four, two appearing near the middle line about the second month, and two some little distance from the middle line about the third month of fetal life. The planum nuchale of the squama is ossified from two centers, which appear about the seventh week of fetal life and soon unite to form a single piece. Union of the upper and lower portions of the squama takes place in the third month of fetal life. An occasional center (Kerckring) appears in the posterior margin of the foramen magnum during the fifth month; this forms a separate ossicle (sometimes double), which unites with the rest of the squama before birth. Each of the

lateral parts begins to ossify from a single center during the eighth week of fetal life. The basilar portion is ossified from two centers, one in front of the other; these appear about the sixth week of fetal life and rapidly coalesce. Mall states that the planum occipitale is ossified from two centers and the basilar portion from one. About the fourth year the squama and the two lateral portions unite, and about the sixth year the bone consists of a single piece. Between the eighteenth and twenty-fifth years the occipital and sphenoid become united, forming a single bone.

ANATOMY OF FORAMEN MAGNUM

The Foramen magnum is situated in the floor of the posterior cranial fossa and surrounded by the parts of the occipital bone; by the basilar part in front, the lateral part on each side, and a small portion of the squama behind. Just in front of its transverse diameter the medial aspects of the occipital condyles encroach it on, so that it is somewhat ovoid in shape and wider behind. Its narrower, anterior part lies above the dens of the axis vertebrae; its wider, posterior part communicates below with the vertebral canal, and through it the medulla oblongata becomes continuous with the spinal cord In front of the foramen magnum the basilar part of the occipital bone, the posterior part of the sphenoidal body and the dorsum sellae form a sloping surface, the clivus, gently concave from side to side, anterior-inferior to the pons and medulla oblongata. On each side this is separated from the petrous part of the temporal bone by the petro-occipital fissure, occupied in life by a thin plate of cartilage. The fissure is limited behind by the jugular foramen, and the inferior petrosal sinus grooves its margins. (37)

The Foramen Magnum provides a wide communication between the posterior cranial fossa and the vertebral canal. Anteriorly the apical ligament of the dens and the membrana tectoria pass through it, both being attached to the upper surface of the basilar part of the occipital bone. Its wider, posterior part transmits the lower end of the medulla oblongata and the meninges. In the subarachniod space the spinal roots of the accessory nerves, and the vertebral arteries, with their sympathetic plexus, ascend into the cranium, and the posterior spinal arteries descend, one on each poster lateral aspect of the brainstem, as does the anterior spinal artery on the front of the brain stem in the median plane. In addition, the lower part of the tonsils of the cerebellum may project into the foramen on each side of the medulla oblongata. The anterior margin of the foramen gives attachment to the anterior atlanto-occipital membrane, which is continuous on each side with the capsular ligament of the atlanto-occipital joint. To the posterior margin is attached to the posterior atlanto-occipital membrane, and to the roughened medial aspect of the condyle, the alar ligament.

In addition to the hypoglossal nerve the hypoglossal canal contains a meningeal branch of the ascending pharyngeal artery and a small emissary vein from the basilar plexus. Not uncommonly the canal s divided in to two by a spicule of bone. The inferior surface of the jugular process of the of the occipital bone provides attachment for the rectus capitis lateralis.

The foramen magnum is a large oval aperture with its long diameter antero-posterior; it is wider behind than in front where it is encroached upon by the condyles. It transmits the medulla oblongata and its membranes, the

accessory nerves, the vertebral arteries, the anterior and posterior spinal arteries, and the membrana tectoria and alar ligaments. 200 skulls from anthropology Museum of GSVM Medical College, Kanpur, U.P., India, were studied to note the variations in the shape of foramen magnum. Foramen magnum was found to be variable in shape: Shapes noted were oval (64%), hexagonal (24.5%), pentagonal (7.5%), irregular (3.5%) and round (0.5%). The findings are hitherto not reported.

The successful identification of the deceased is vital to the progress of any forensic investigation. One of the principal biological traits to be established from skeletal remains is the sex of the individual. This becomes more difficult if only parts of a skeleton are found or if the bones are compromised by physical insults such as fire, explosions or violence. The basal region of the occipital bone is covered by a large volume of soft tissue and is therefore in a relatively well-protected anatomical position, and as such, classification of sex using the occipital bone may prove useful in cases of significantly disrupted remains.

The base of the cranium is so complex that it is very interesting to study the diameters of the foramen magnum, from descriptive and topographic points of view, due to the important relation of the foramen magnum with its contents. Additionally, the dimensions of the foramen magnum have clinical importance because the vital structures that pass through it may suffer compression such as in case of foramen magnum Achondroplasia and foramen magnum brain herniation.(39,40 41) In a transcondylar surgical approach to the foramen magnum, such as in the resection of tumors of the foramen magnum region,

surgeries on posterior fossa growths the anatomic features of the foramen magnum and variations in the condylar resections to improve the exposure of this region have been considered in several studies.(42-44) Wanebo et al. stated that longer foramen magnum anterior-posterior dimensions permitted greater contra lateral surgical exposure for condylar resection.(45) The anatomic and radio logic values of the foramen magnum have been the objectives of several studies. Although the anatomic values obtained by different authors are nearly the same, this does not happen with radiological values.(46) The values radio graphically obtained by Munoz were about 0.5mm higher than the anatomic values.(47) The radio logic mean values obtained by Schmeltzer et al. and wackenheim were 35mm for the sagittal diameter and 30mm for the transverse diameter, whereas Zaragoza obtained mean values of 38mm for the sagittal diameter and 28mm for the transverse diameter.(48,49,50) Classically, the anatomic diameters have been found to be about 35mm for the sagittal diameter and 30mm for the transverse diameter. (51,52) A study conducted at St. Bride's church, London utilized Eighteenth to Nineteenth century documented skeletal collection. It was found for a set of 33 skull the sagittal and transverse diameter were found to be35.6±2.3mm and 29.9±2.1mm.Another study conducted at Madurai by Muthukumar N. Swami Nathan et al using skulls at the extra cranial ends got the following values for the sagittal diameter it was 33.3mm and for the transverse diameter it was 27.9mm.(53) Considering the above-mentioned values, the aim of the present study was to evaluate the metric values of the Foramen magnum and their relation to the sex.

AIM OF THE STUDY

1. To Measure the Sagittal diameter and the Transverse diameter of the Foramen magnum intracranially during Autopsy of south Indian population done at Government General Hospital, Chennai -3.

2. To Study the possibility of sex determination in the South Indian population using these measurements.

3. To Study the possibility of age determination in the South Indian population using these measurements.

MATERIALS AND METHODS

The present study was conducted in the Institute of forensic medicine, Madras Medical College during 2007-2008. The study was approved by the Institutional Ethical Committee, Govt. General Hospital & Madras Medical College, Chennai.

The study sample consists of 420 human bodies comprising of 260 male and 160 female bodies in the age group of 18-60 years. On receiving requisition for the autopsy from the concerned Investigating officer the autopsies were conducted at the dissecting hall of the Madras Government General Hospital mortuary.

The age range of 18-60 years was selected. The sexual characteristics of the bone do not begin to manifest themselves until the stage of puberty is attained. Hence the lower limit of age was fixed as 18 years. Since all the sutures of the cranium get fused by 60 years of age, the upper limit was fixed at 60years.

INCLUSION CRITERIA

1. Age group of 18-60 years
2. With out any fracture of the cranium.

EXCLUSION CRITERIA

1. Age less than 18 years.
2. Age above 60 years.
3. Fracture involving the base of the cranium.
4. Congenital anomalies.
5. Dwarfs.

INSTRUMENTS

1. Scalpel,
2. Oscilating saw,
3. Divider-for the measurement of internal diameter.
4. Sliding Vernier Caliper.

METHODS (54,55)

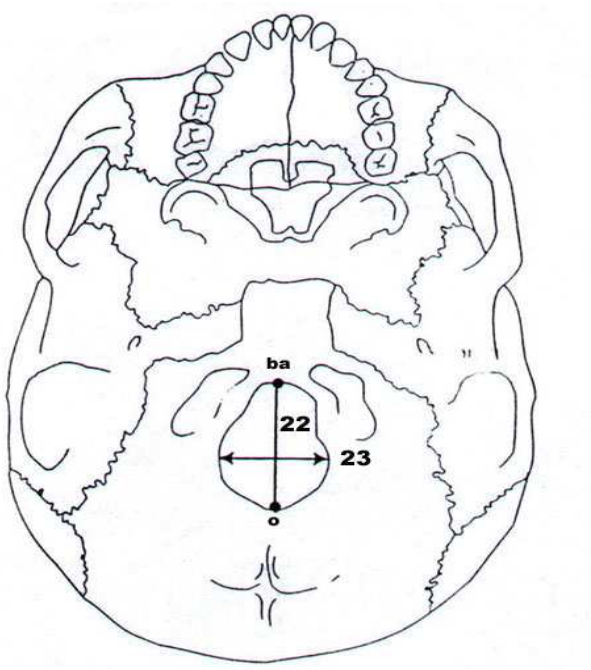
After completing the external examination the head was elevated using the headrest. An incision was given on one side just behind the ear lobe, as low as possible and extended to a comparable level on the other side. Cutting the whole thickness of the scalp using the scalpel blade. The anterior and posterior halves of the scalp were then reflected forwards and backwards respectively. The Temporalis muscle was cut down with the help of a sharp knife.

Then the cranium was opened using an oscillating saw. The frontal point of sawing was started approximately two fingers breath above the supraorbital ridge and then the head turned to the opposite side and sawing extended to the temporal point. Finally over the occipital area approximately two finger breaths above the external occipital protuberance sawed. A hand inserted between the cranium and the dura helps the blunt separation of these while the other hand was pulling the cranial cap. The dura was peeled off. Then raising the frontal lobes gently and tearing the olfactory bulbs and tracts away from the cribriform plates removed the brain. The Optic nerve, Pituitary stalk, Internal carotid arteries, Third, fourth, Fifth and Sixth cranial nerves and Subdural communicating veins were severed close to the base of the skull. The attachment of Tentorium along the Petrous ridge cut on either side with curved

scissors. The cervical part of the Spinal cord was cut down with curved scissors as caudally as possible. The Brain was pulled away from the base of the skull after cutting the lateral attachment of the tentorium to the Petrous bone along with the Pineal body. The adherent duramatter was completely removed from the base of the skull. The remnant tissues along the Foramen magnum's rim were also completely removed.

BASION (ba): The midline point on the anterior margin of the foramen magnum. For cranial height measurements, the point is placed on the anteroinferior portion of the foramen's rim. For basinasal and basiprosthion measurements, the point is located on the most posterior point on the foramen's anterior rim and is sometimes distinguished as endobasion.56

OPISTHION (o): The midline point at the posterior margin of the foramen BAS Skull. The Foramen magnum margins were cleared off from remnant tissues.



22. Foramen Magnum Length (ba-o): direct distance from basion (ba) to opisthion (o)

23. Foramen Magnum Breadth: distance between the lateral margins of foramen magnum at the points of greatest lateral curvature.

Procedure

The anterior-Posterior and transverse diameter was measured using divider and sliding vernier caliper. Since the vernier caliper cannot be used directly for the measurement of the sagittal and transverse diameter of the foramen magnum, the divider is used to take the measurement.

Measurement of the Sagittal diameter

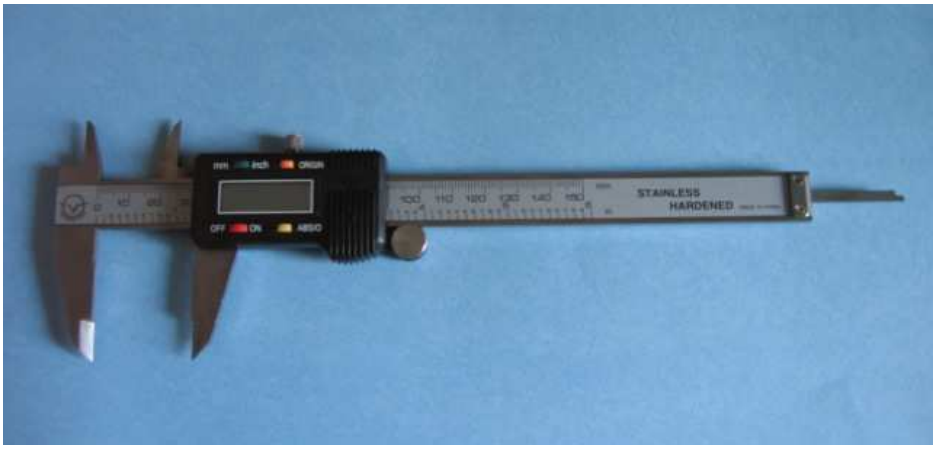
The ends of the divider was fixed at the Basion i.e. the midline point on the anterior margin of the Foramen magnum and the Opisthion i.e. the midline point at the posterior margin of the Foramen magnum. The distance between the ends of the divider is measured in mm using the Sliding Vernier caliper.

Measurement of Transverse diameter

The ends of the divider are fixed at the points of the greatest lateral curvature of the both side lateral margins of the Foramen magnum. The distance between the ends of the divider is measured in mm using the Sliding Vernier caliper

DIVIDER

SLIDING VERNIER CALIPER



DIVIDER WITH VERNIER CALIPER

BASE OF THE SKULL

TAKING MEASUREMENTS AT BASE OF SKULL

RESULTS

In this study 420 routine autopsies done at the mortuary of Government general hospital, Chennai-3. were taken for the measurements of various parameters like Head circumference, Sagittal diameter and Transverse diameter of the Foramen magnum. The master chart shows all the data of the 420 cases collected for this study

The sex distribution among the total 420 cases as follows male 260 cases and female 160 cases. This constitutes 61.9 % of males and 38.1 %of females and this is given in Table 1.

The age wise distribution with percentage among the male and female cases was given in table 2 and table 3 respectively. The number of cases in the 18-30 years subgroup constitutes 37.6 %[158 cases] of the total sample size. Likewise in the 31-40 years subgroup the cases constitutes 20.48 % [86 cases], in the 41-50 years subgroup the cases were 25.72% [108cases] and in the 51-60 years subgroup the cases constitute 16.20 %[68cases] of the total sample size.

The mean ± S.D for the sagittal diameter, transverse diameter and head circumference were 18.08±0.904mm, 25.75±3.161mm and 54.54±0.712cm respectively for the 420 cases is given in Table 4. The mean±S.D, the maximum and the minimum values for all the parameters in male and female groups were given in table 5 and 6 respectively. The mean ±S.D for all the parameters of age wise male and female groups were given in table 8 and table 9 respectively.

TABLE - 1

Sex Distribution of the Study Group

Category	Number	Percentage
Male	260	61.9
Female	160	38.1
Total	**420**	**100**

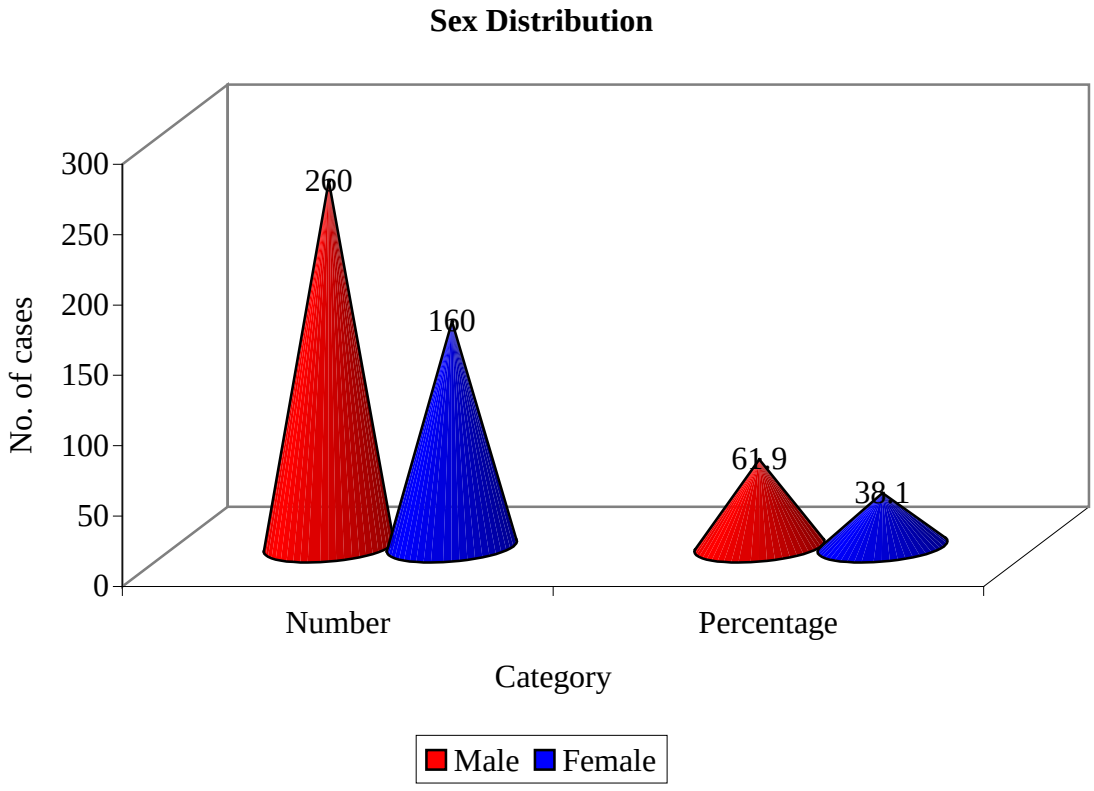


TABLE - 2

Age wise Percentage of Male Cases

S.No	Age in years	No. of Cases	Percentage
1	18- 30	84	32.3
2	31- 40	60	23.0
3	41- 50	72	27.7
4	51- 60	44	17.0

Age wise Percentage of Male Cases

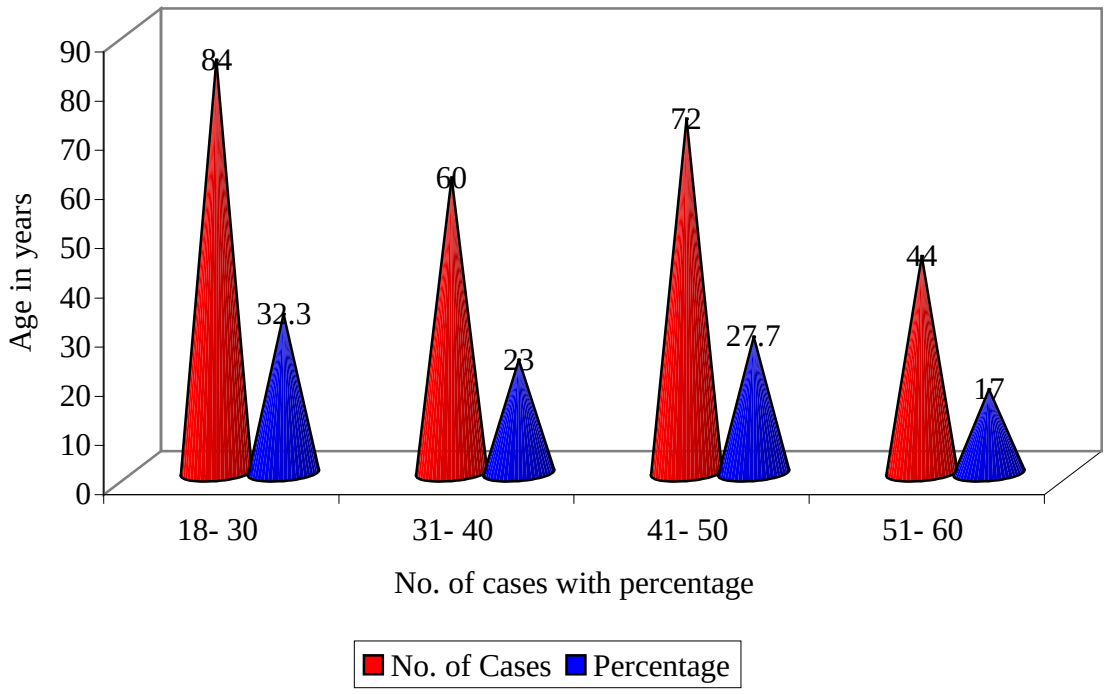


TABLE - 3

Age Wise Percentage of Female Cases

S.No	Age in years	No. of cases	Percentage
1	18-30	74	46.3
2	31-40	26	16.2
3	41-50	36	22.5
4	51-60	24	15.0

Age wise Percentage of Female Cases

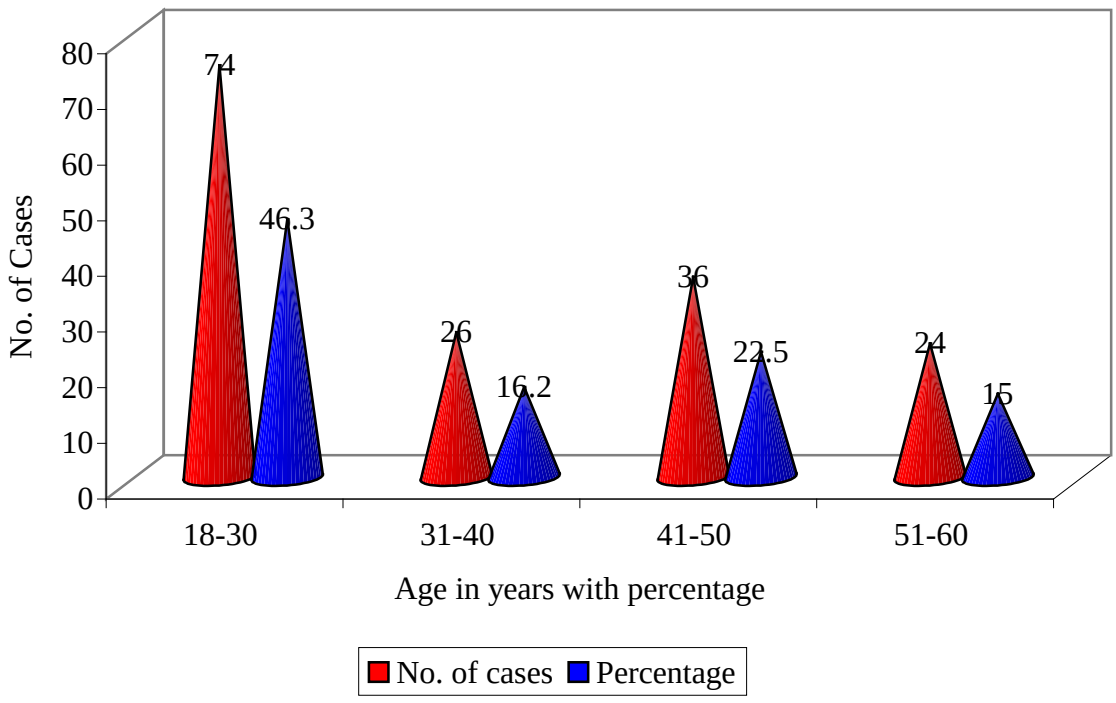


TABLE - 4

Average ± S.D. of all the Parameters in 420 Cases

Parameters	Mean ± S.D.
Sagittal diameter (mm)	18.08 ± 0.904
Transverse diameter (mm)	25. 75 ± 3.161
Head circumference (cm)	54.54 ± 0.712

TABLE - 5

Average ± S.D. of the Parameters in Male Cases (No = 260)

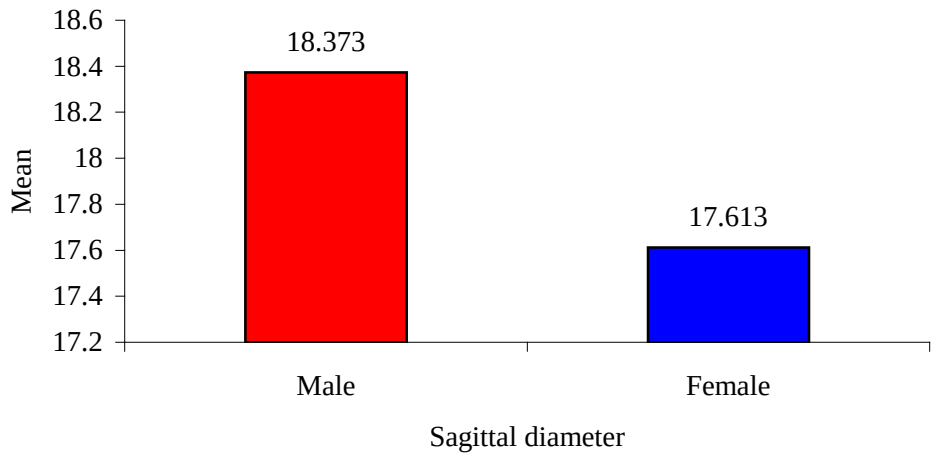
Parameters	Maximum	Minimum	Mean ± S.D.
Sagittal diameter (mm)	21	17	18.373 ± 0.716
Transverse diameter (mm)	30	27	28.177 ± 0.627
Head circumference (cm)	56	54	54.896 ± 0.513

TABLE - 6

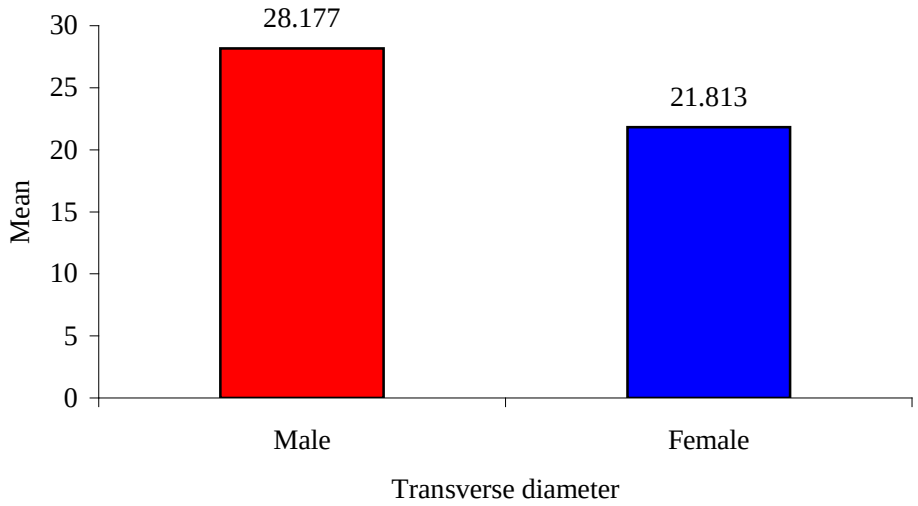
Average ± S.D. of the Parameters in Female Cases (No =160)

Parameters	Maximum	Minimum	Mean ± S.D
Sagittal diameter (mm)	21	16	17.613 ± 0.978
Transverse diameter (mm)	23	20	21.813 ± 0.684
Head circumference (cm)	55	52	53.878 ± 0.640

Sagittal diameter in Male and Female



Transverse diameter in Male and Female



Head circumference in Male and Female

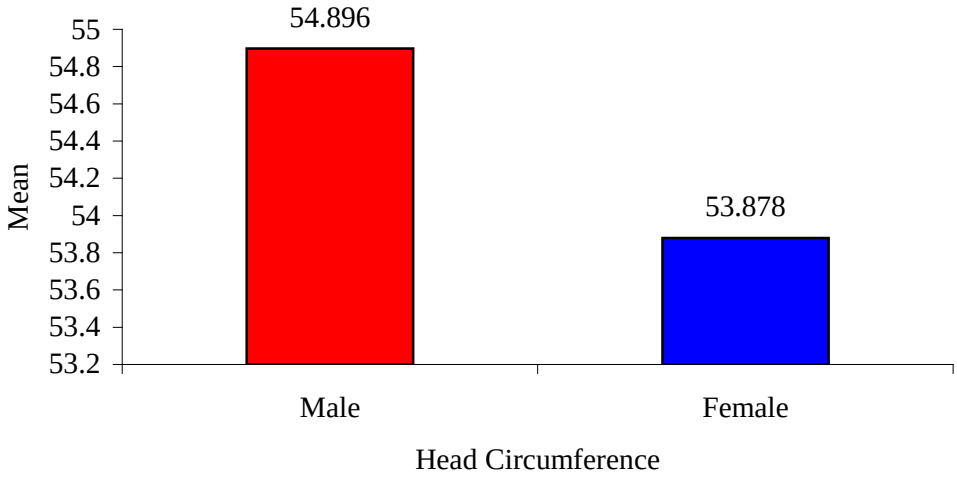


TABLE - 7

Comparison of Male Vs Female Group

Parameters Mean ± SD	Male	Female	p value	Significance
Head circumference (cm)	54.896 ± 0.513	53.878 ± 0.64	> 0.5	NS
Sagittal diameter (mm)	18.373 ± 0.716	17.613 ± 0.978	> 0.5	NS
Transverse diameter (mm)	28.177 ± 0.627	21.813 ± 0.684	< 0.001	HS

TABLE - 8

Average ± SD of all the parameters in male age wise sub groups

Age in years	Head circumference (cm)	Sagittal diameter (mm)	Transverse diameter (mm)
18 -30	54.893 ± 0.538	18.405 ± 0.661	28.131 ± 0.636
31 - 40	54.867 ± 0.503	18.533 ± 0.965	28.200 ± 0.755
41 - 50	54.889 ± 0.491	18.250 ± 0.600	28.181 ± 0.565
51 - 60	54.955 ± 0.526	18.295 ± 0.553	28.227 ± 0.522

TABLE - 9

Average ± SD of all the parameters in female age wise sub groups

Age in years	Head circumference (cm)	Sagittal diameter (mm)	Transverse diameter (mm)
18 -30	53.878 ± 0.640	17.527 ± 0.831	21.784 ± 0.668
31 - 40	53.808 ± 0.491	17.500 ± 0.949	21.846 ± 0.675
41 - 50	54.194 ± 0.577	17.690 ± 1.090	21.806 ± 0.749
51 - 60	54.042 ± 0.550	17.875 ± 1.227	21.875 ± 0.680

TABLE - 10

Comparison of male vs. female in the age group of 18-30 years.

Parameters - Mean ±SD	Male	Female	p value	Significance
Head circumference (cm)	54.893 ± 0.538	53.878 ± 0.640	< 0.001	HS
Sagittal diameter (mm)	18.405 ± 0.661	17.527 ± 0.831	< 0.001	HS
Transverse diameter (mm)	28.131 ± 0.636	21.783 ± 0.668	< 0.001	HS

TABLE - 11

Comparison of male vs. female in the age group of 31 - 40 years.

Parameters Mean ±SD	Male	Female	p value	Significance
Head circumference (cm)	54.867 ± 0.503	53.808 ± 0.492	< 0.001	HS
Sagittal diameter (mm)	18.533 ± 0.965	17.500 ± 0.949	< 0.001	HS
Transverse diameter (mm)	28.200 ± 0.754	21.846 ± 0.675	< 0.001	HS

TABLE - 12
Comparison of male vs. female in the age group of 41 - 50 years.

Parameters Mean ± SD	Male	Female	p value	Significance
Head circumference (cm)	54.889 ± 0.491	54.194 ± 0.577	< 0.001	HS
Sagittal diameter (mm	18.250 ± 0.600	17.690 ± 1.09	< 0.001	HS
Transverse diameter (mm)	28.181 ± 0.565	21.806 ± 0.749	< 0.001	HS

TABLE - 13

Comparison of male vs. female in the age group of 51 - 60 years

Parameters – Mean ± SD	Male	Female	p value	Significance
Head circumference (cm)	54.9546 ± 0.526	54.042 ± 0.550	< 0.001	HS
Sagittal diameter (mm)	18.296 ± 0.553	17.875 ± 1.227	> 0.1	NS
Transverse diameter (mm)	28.227 ± 0.522	21.875 ± 0.680	< 0.001	HS

TABLE - 14

Comparison of 18 - 30 years vs. 31 - 40 of male group

Parameters – Mean ±SD	18-30 years	31-40 years	p value	Significance
Head circumference (cm)	54.893 ± 0.538	54.867 ± 0.503	> 0.1	NS
Sagittal diameter (mm)	18.405 ± 0.661	18.533 ± 0.965	> 0.1	NS
Transverse diameter (mm)	28.131 ± 0.636	28.200 ± 0.755	> 0.1	NS

TABLE - 15

Comparison of 18 - 30 years vs. 41- 50 years of male group.

Parameters – Mean ±SD	18-30 years	41-50 years	p value	Significance
Head circumference (cm)	54.893 ± 0.538	53.889 ± 0.491	> 0.1	NS
Sagittal diameter (mm)	18.405 ± 0.661	18.250 ± 0.600	> 0.1	NS
Transverse diameter (mm)	28.131 ± 0.636	28.181 ± 0.521	> 0.1	NS

TABLE - 16

Comparison of 18 - 30 years vs. 51- 60 years of male group

Parameters – Mean ± SD	18-30 years	51-60 years	p value	Significance
Head circumference (cm)	54.893 ± 0.538	54.955 ± 0.526	> 0.1	NS
Sagittal diameter (mm)	18.405 ± 0.6661	18.296 ± 553	> 0.1	NS
Transverse diameter (mm)	28.131 ± 0.636	28.227 ± 0.522	> 0.1	NS

TABLE - 17

Comparison of 31- 40 years vs. 41- 50 years of male group

Parameters – Mean ±SD	31- 40 years	41-50 years	p value	Significance
Head circumference (cm)	54.867 ± 0.503	54.889 ± 0.491	> 0.1	NS
Sagittal diameter (mm)	18.533 ± 0.965	18.250 ± 0.599	< 0.05	S
Transverse diameter (mm)	28.200 ± 0.755	28.181 ± 0.565	> 0.1	NS

TABLE - 18

Comparison of 31 - 40 vs. 51- 60 years of male group

Parameters – Mean ± SD	31- 40 years	51- 60 years	p value	Significance
Head circumference (cm)	54.867 ± 0.503	54.955 ± 0.526	> 0.1	NS
Sagittal diameter (mm)	18.533 ± 0.965	18.296 ± 0.553	> 0.1	NS
Transverse diameter (mm)	28.2 ± 0.755	28.227 ± 0.522	> 0.1	NS

TABLE - 19

Comparison of 41-50 vs. 51- 60 years of male group

Parameters – Mean ± SD	41-50 years	51- 60 years	p value	Significance
Head circumference (cm)	54.889 ± 0.491	54.955 ± 0.526	> 0.1	NS
Sagittal diameter (mm)	18.250 ± 0.599	18.296 ± 0.553	> 0.1	NS
Transverse diameter (mm)	28.181 ± 0.565	28.227 ± 0.522	> 0.1	NS

TABLE - 20

Comparison of 18 - 30 vs. 31- 40 years of female group

Parameters Mean ± SD	18-30 years	31-40 years	p value	Significance
Head circumference (cm)	53.878 ± 0.640	53.808 ± 0.492	> 0.1	NS
Sagittal diameter (mm)	17.527 ± 0.831	17.500 ± 0.949	> 0.1	NS
Transverse diameter (mm)	21.784 ± 0.668	21.846 ± 0.675	> 0.1	NS

TABLE - 21

Comparison of 18 - 30 vs. 41- 50 years of female group.

Parameters – Mean ± SD	18-30 years	41-50 years	p value	Significance
Head circumference (cm)	53.878 ± 0.640	54.194 ± 0.577	< 0.01	HS
Sagittal diameter (mm)	17.527 ± 0.831	17.690 ± 1.091	> 0.1	NS
Transverse diameter (mm)	21.784 ± 0.668	21.806 ± 0.749	> 0.1	NS

TABLE - 22

Comparison of 18 - 30 years vs. 51- 60 of female group

Parameters – Mean ± SD	18-30 years	51- 60 years	p value	Significance
Head circumference (cm)	53.878 ± 0.640	54.041 ± 0.550	> 0.1	NS
Sagittal diameter (mm)	17.527 ± 0.831	17.875 ± 1.227	> 0.1	NS
Transverse diameter (mm)	21.784 ± 0.668	21.875 ± 0.680	> 0.1	NS

TABLE - 23

Comparison of 31- 40 vs. 41-50 years of female group.

Parameters – Mean ± SD	31- 40 years	41- 50 years	p value	Significance
Head circumference (cm)	53.808 ± 0.492	54.194 ± 0.577	< 0.01	HS
Sagittal diameter (mm)	17.500 ± 0.949	17.690 ± 1.091	> 0.1	NS
Transverse diameter (mm)	21.846 ± 0.675	21.806 ± 0.749	> 0.1	NS

TABLE - 24

Comparison of 31- 40 vs.51- 60 years of female group

Parameters – Mean ± SD	31- 40 years	51- 60 years	p value	Significance
Head circumference (cm)	53.808 ± 0.492	54.042 ± 0.550	> 0.1	NS
Sagittal diameter (mm)	17.500 ± 0.949	17.875 ± 1.227	> 0.1	NS
Transverse diameter (mm)	21.846 ± 0.675	21.875 ± 0.680	> 0.1	NS

TABLE - 25

Comparison of 41-50 vs. 51- 60 years of female group.

Parameters – Mean ± SD	41- 50 years	51- 60 years	p value	Significance
Head circumference (cm)	54.194 ± 0.577	54.042 ± 0.550	> 0.1	NS
Sagittal diameter (mm)	17.690 ± 1.091	17.875 ± 1.227	> 0.1	NS
Transverse diameter (mm)	21.806 ± 0.749	21.875 ± 0.680	> 0.1	NS

The comparison of mean± S.D of all the three parameters, the p-value and its significance for male and female cases in the subgroup of 18-30 years, 31-40 years, 41-50 years and 51-60 years were given in table -10,11 12 and 13 respectively. The comparison of mean±S.D of all the three parameters for the male cases between 18-30 and 31-40 years subgroup were given in table 14. Similarly the comparison of 18-30 years and 41-50 years, 18-30 years and 51-60 years, 31-40 years and 41-50 years, 31-40- years and 51-60 years and 41-50 years and 51-60 years subgroups with p-value and its significance were given in table 15,16,17,18 and table 19 respectively. The comparison of mean± S.D of all the three parameters of the female cases in 18-30 years and 31-40 years, 18-30 years and 41-50 years, 18-30 years and 51-60 years, 31-40 years and 41-50 years, 31-40 years and 51-60 years and 41-50 years and 51-60 years subgroups, p-value and its significance were given in table 20, 21, 22, 23,24 and table 25 respectively. The Head circumference in case of male was found to be 54.9cm and in female it was 53.9cm.

All the case taken in this study belongs to the south Indian population; no religious preference was given in this study. The sagittal diameter was found to be more in males than in females. The transverse diameter was found to be significantly greater in males than in females. In males the mean ±standard deviation was 18.373±0.716mm and 28.177±0.627mm for the sagittal diameter and transverse diameter respectively. In females this was found to be 17.613±0.978mm and 21.813±0.684mm.respectively.The head circumference was found more in male than in female the mean with standard deviation for male was54.896±0.513cm and for female 53.878 ± 0.640cm

DISCUSSION

In this study of 420 skulls of south Indian population the Transverse diameter of the Foramen magnum for both male and female cases put together is 25.7±3.2 mm is obtained. In males, 30mm and 27mm were obtained as the maximum and minimum values for the transverse diameter respectively. In females, 23mm and 20mm were obtained as the maximum and minimum values respectively. The mean in male group was 28.177±0.627mm and in female group the mean was 21.813±0.684mm. This result was in close agreement with Catalina Herrera's anatomic study of the Foramen magnum in which the transverse diameter of Foramen magnum was found to be 30.3mm (46). Testut and Latarjet obtained similar values(52). The above values were also consistent with results obtained by Schmeltzer et al and Wackenheim Sendemirct et al study in which they obtained a mean value of 30mm for the transverse diameter of the Foramen magnum by C.T.image study(48,49). Fischgold and Werekenheim reported that the minimum radiographic value for the transverse diameter as 30mm(57).Another study conducted at Madurai, India by Muthukumar .N. Swami Nathan et al gives a value of 27.9mm for the transverse diameter of the Foramen magnum. Other authors give values for the Transverse diameter of the Foramen magnum between 21.4mm and 40mm.Khalil Awadh Murshed et al of Turkey in their study obtained 40mm and 33mm as the maximum and 27mm and 24mm as the minimum values for the transverse diameter for male and female respectively (58).

According to Martin and Sellar, the difference in the measurements between the living and skeletal bones is because of drying up of the bones. He further says that in the skull all the dimensions differ by 1-2% on drying. Since in the present study the measurements were taken from wet skull, if the above variation is calculated the difference between the mean value of the transverse diameter of the Foramen magnum of the present study and the other quoted study will be minimal. The above quoted studies were done on European population, which could be the reason for the small variation. In the above quoted studies the measurements were taken at the lower edge of the foramen magnum extra cranially where as in the present study the measurements were taken at the upper edge of the foramen magnum intra cranially. This could be the reason for the difference in the transverse diameter between the present and above quoted studies or could be due to the population difference.

There is a difference of 6.364mm between the mean values of the transverse diameter of Foramen magnum of male and female. On statistical analysis the difference is found to be highly significant with the p- value of less than 0.001 by z-test.

Each group is again divided in to four subgroups based on age and the subgroup mean with standard deviation was calculated for the transverse diameter. In the 18-30 years subgroup the transverse diameter for male was 28.131±0.636mm and for female this was found to be 21.783 ± 0.668mm.There is a difference of 6.348mm which is statistically significant. Similarly in the 31-40 years subgroup the Transverse diameter in male was 28.200±0.754mm and for female this was 21.846±0.675mm and there is a difference of 6.354mm

and this is statistically significant. In the 41-50 years subgroup the Transverse diameter was found to be 28.181±0.565mm and in females this was found to be 21.806±0.749mm. The difference was 6.375mm and this is statistically significant. In the 51-60 years subgroup the value of the Transverse diameter in males was 28.227± 0.522mm and in females 21.875±0.680mm and the difference was 6.352mm which is statistically significant. The difference between Transverse diameters of all the male and female subgroups is found to be 6.350 mm.

In the 18-30 years male subgroup the Transverse diameter was 28.131 and in the 31-40 years male subgroup this was 28.200 and the difference was found to be 0.069mm, which is statistically not significant. Similarly between the 18-30 years and 41-50 years subgroup the difference is 0.05mm, which is statistically not significant. Between the 18-30 years and 51-60 years subgroups the difference was 0.096 mm, which is statistically not significant. The difference in the Transverse diameter 31-40 years and 41-50 years male subgroup was found to be 0.019mm and this is statistically not significant. Similarly in the female subgroups the difference in the transverse diameter was found statistically not significant. Each male subgroup was compared with corresponding female subgroup. Each subgroup difference was approximately 6.3mm, which was almost equal to the difference between male and female group. Statistical analysis by z-test the p-value obtained was less than 0.001 and the difference was very much significant. Among the male subgroup the mean difference in the transverse diameter was found to be less than 0.05mm, which was not significant. On statistical analysis the z-value obtained was 0.47

but z-value of equal or more than 2.5 is only significant. Among the female subgroup the mean difference in the transverse diameter was found to be less than 0.05mm, which was not significant. On statistical analysis the z-value obtained was 0.32 but z-value of equal or more than 2.5 is only significant. Hence it is very difficult to obtain the correct age of the deceased using the transverse diameter of the foramen magnum.

Hence based on the transverse diameter of the Foramen magnum, the sex determination can be done with 99.9% confidence limit.

The mean value of 18.08±0.904mm is obtained for the sagittal diameter of the foramen magnum for both male and female cases put together [420 cases]. In male, 21mm and 17mm were obtained as the maximum and minimum vales for the sagittal diameter. In case of females these values were 21mm and 16mm.The mean in male was18.373±0.716mm and the mean in females was 17.613±0.978mm. The value is very much differing from the above quoted studies. Catalina-Herrera's anatomic study of the Foramen magnum the sagittal diameter was found to be 35.2mm.Similar values were obtained by Testut and Latarjet. The study conducted by Khaliil Awadh Murshed et al of Turkey obtained values of 28-31mm for the sagittal diameter by C.T. image study. Schmeltzer et al. and Wackenheim Sendemir et al, Fischgold and wackenhim obtained values between 27mm and 36.4mm.In the above quoted studies the measurements were taken at the lower edge of the foramen magnum extra cranially where as in the present study the measurements were taken at the upper edge of the foramen magnum intra cranially. This could be the reason for the large difference in the sagittal

diameter between the present and above quoted studies or this could be due to the population difference. This can be verified only when a similar study is done in the south Indian population. The Sagittal diameter was found to be 18.373mm for males and 17.613mm for females and a difference of 0.76mm was obtained which is statistically not significant.

Each group is again divided in to four subgroups based on age and the subgroup mean with standard deviation was calculated for the sagittal diameter. Each male subgroup was compared with corresponding female subgroup. Each subgroup difference was approximately 0.79mm, which was almost equal to the difference between male and female group, and the difference was statistically not significant.

Among the male subgroup the mean difference in the sagittal diameter was found to be less than 0.15mm which was statistically not significant. Among the female subgroup the mean difference in the sagittal diameter was found to be less than 0.50mm which was statistically not significant.

The mean value of Head circumference including the Scalp in male was found to be 54.9cm and in female it was 53.9cm. There is a difference of 1cm between male and female cases .On statistical analysis the difference is found to be significant.

The shape of the Foramen magnum intracranially is horizontally oval both on visual inspection and based on the measurements. Zaidi and Dayal reported that oval Foramen magnum was found in 64% of Indian population (59). Sindel et al. and Lang et al. reported that this shape was not found in

more than 22.35% and 18.94% respectively(60). The Foramen magnum was hexagonal in 24.5%, pentagonal in 7.5%, irregular in 3.5% and round in 0.5% of the skulls studied by Zaidi and Dayal, whereas in the skulls studied by Sindel et al. the Foramen magnum was hexagonal in 5.2%, pentagonal in 4.2%, irregular in 6.3%, round in 15.8% and tetragonal in 49.4%.

CONCLUSION

1. The Sagittal diameter of the South Indian population of Male (260 in no) is18.4mm and of Female (160 in no) is 17.6mm.

2. The Transverse diameter of the South Indian population of Male is 28.2mm and of Female is 21.8mm.

3. The Transverse diameter of the Foramen Magnum can be used to differentiate the sex with of a 99.9% of confidence level.

4. The sex of an individual cannot be determined based on sagittal diameter of Foramen Magnum.

5. The age of an individual cannot be determined based on the Transverse and Sagittal diameter of the Foramen magnum.

6. The shape of the Foramen magnum is horizontally oval in both sexes of the South Indian population.

MASTER CHART

S.No	P.M .No	Age	H.C cm	S.D. mm	T.D. mm
1	387/07	43	55	16	20
2	446/07	25	54	17	21
3	774/07	20	53	16	20
4	813/07	60	54	16	22
5	876/07	23	55	17	21
6	922/07	26	54	17	21
7	1041/07	46	53	18	22
8	1064/07	30	55	17	22
9	1147/07	40	53	16	23
10	1202/07	38	54	17	22
11	1516/07	24	54	18	22
12	1586/07	60	55	16	20
13	1595/07	22	53	17	21
14	1598/07	27	54	17	22
15	1643/07	21	53	17	22
16	1647/07	20	52	17	21
17	1803/07	20	54	18	22
18	1816/07	48	55	18	23
19	1820/07	40	54	17	22
20	1883/07	45	55	17	22
21	1889/07	45	54	17	21
22	1986/07	60	55	18	22
23	1998/07	60	54	18	23
24	2004/07	22	54	16	21
25	2062/07	25	55	17	22
26	2072/07	23	53	17	22
27	2080/07	32	53	18	22
28	2098/07	35	54	16	21
29	2128/07	35	54	16	22
30	2176/07	29	55	16	23
31	2265/07	41	55	16	22
32	2291/07	21	54	16	21

S.No	P.M .No	Age	H.C cm	S.D. mm	T.D. mm
33	2324/07	19	54	17	22
34	2344/07	23	54	16	22
35	2396/07	30	54	17	22
36	34/08	34	53	17	23
37	39/08	43	55	17	21
38	85/08	32	54	16	22
39	156/08	35	54	17	22
40	186/08	28	54	17	21
41	230/08	18	54	17	21
42	242/08	24	54	18	22
43	248/08	40	54	17	23
44	270/08	24	55	17	22
45	271/08	44	54	16	22
46	275/08	51	54	17	22
47	290/08	60	53	18	22
48	301/08	48	55	17	21
49	344/08	52	54	17	22
50	372/08	54	53	16	22
51	391/08	58	54	17	22
52	396/08	45	54	16	21
53	410/08	21	55	16	22
54	411/08	60	54	17	22
55	417/08	50	55	17	22
56	476/08	60	54	18	23
57	477/08	26	54	18	22
58	480/08	27	53	16	21
59	506/08	49	54	17	22
60	517/08	60	54	17	22
61	531/08	43	54	17	20
62	533/08	45	54	17	21
63	559/08	49	55	18	21
64	553/08	46	54	18	22
65	563/08	43	54	17	22
66	576/08	35	53	16	22

S.No	P.M .No	Age	H.C cm	S.D. mm	T.D. mm
67	586/08	21	53	16	22
68	589/08	60	54	19	21
69	628/08	26	54	17	22
70	670/08	28	53	18	23
71	688/08	19	54	16	22
72	696/08	45	54	17	21
73	747/08	27	54	17	21
74	748/08	60	53	18	22
75	752/08	22	54	17	22
76	775/08	60	55	18	21
77	802/08	18	54	18	22
78	813/08	30	54	18	22
79	859/08	35	54	18	22
80	921/08	21	54	18	21
81	932/08	57	54	17	22
82	939/08	20	54	18	22
83	947/08	22	53	18	22
84	949/08	50	54	18	22
85	951/08	36	54	18	21
86	956/08	39	53	17	22
87	1035/08	19	54	18	21
88	1059/08	45	54	18	22
89	1089/08	21	54	18	21
90	1119/08	20	53	18	22
91	1132/08	20	55	18	23
92	1401/08	27	54	18	22
93	1160/08	55	54	19	22
94	1176/08	22	53	18	22
95	1194/08	50	54	18	21
96	1225/08	48	54	17	22
97	1241/08	55	54	18	22
98	1243/08	25	55	18	23
99	1274/08	33	54	18	22
100	1284/08	40	54	18	21

S.No	P.M .No	Age	H.C cm	S.D. mm	T.D. mm
101	1289/08	30	54	18	22
102	1324/08	49	54	18	22
103	1332/08	60	54	19	21
104	1341/08	23	54	20	20
105	1348/08	21	53	18	21
106	1395/08	18	54	18	22
107	1408/08	28	53	18	22
108	1420/08	25	54	17	22
109	1421/08	46	54	18	23
110	1424/08	35	54	18	22
111	1437/08	44	54	18	22
112	1443/08	20	54	18	22
113	1456/08	26	53	19	21
114	1467/08	22	54	18	22
115	1478/08	19	53	18	22
116	1481/08	22	54	17	22
117	1494/08	20	54	18	21
118	1498/08	42	54	18	22
119	1499/08	49	53	18	22
120	1524/08	37	54	18	21
121	1525/08	57	54	18	23
122	1538/08	30	54	18	22
123	1562/08	22	53	17	22
124	1592/08	38	54	19	21
125	1599/08	35	54	18	20
126	1601/08	48	55	18	22
127	1609/08	25	54	19	21
128	1613/08	50	54	20	23
129	1614/08	35	53	18	22
130	1625/08	25	54	18	22
131	1626/08	19	54	19	21
132	1630/08	29	54	18	22
133	1637/08	37	54	18	22
134	1651/08	19	53	18	23

S.No	P.M .No	Age	H.C cm	S.D. mm	T.D. mm
135	1663/08	45	55	21	22
136	1666/08	21	54	18	22
137	1669/08	35	54	19	22
138	1671/08	24	54	17	22
139	1692/08	50	54	18	23
140	1721/08	30	54	18	21
141	1723/08	22	54	18	22
142	1725/08	18	54	19	23
143	1730/08	28	54	18	22
144	1740/08	23	53	18	23
145	1744/08	40	55	18	22
146	1773/08	28	54	17	22
147	1777/08	26	55	18	23
148	1781/08	50	54	18	22
149	1783/08	50	54	19	22
150	1816/08	54	54	18	21
151	1826/08	45	53	18	22
152	1838/08	29	55	18	22
153	1839/08	50	54	20	23
154	1848/08	60	55	21	22
155	1872/08	60	54	20	22
156	1876/08	60	54	19	22
157	1901/08	40	54	18	22
158	1931/08	48	54	18	22
159	1944/08	18	54	18	22
160	1946/08	40	54	19	22
	Total	**5757**	**8634**	**2818**	**3490**
	Mean	**35.98125**	**53.9625**	**17.6125**	**21.8125**
	Std dev	**13.49562**	**0.602797**	**0.977659**	**0.683935**

HC – Head circumference;
SD – Sagittal diameter;
TD – Transverse diameter.
PM No – Postmortem number.

MASTER CHART

Sl.No	P.M.No	Age	HC cm	SD mm	TD mm
161.	1/08	41	55	18	28
162.	2/08	21	55	18	28
163.	3/08	30	54	19	28
164.	4/08	22	55	18	28
165.	5/08	43	55	18	27
166.	7/08	24	56	19	28
167.	11/08	19	55	18	28
168.	20/08	40	55	17	28
169.	33/08	33	54	18	26
170.	54/08	51	54	18	28
171.	63/08	42	55	18	28
172.	83/08	20	55	19	28
173.	89/08	29	54	18	27
174.	103/08	35	54	18	26
175.	113/08	38	55	17	28
176.	114/08	43	56	18	28
177.	116/08	60	55	18	28
178.	112/08	54	55	18	28
179.	120/08	40	55	18	28
180.	146/08	29	55	18	27
181.	154/08	35	54	18	29
182.	155/08	24	55	18	29
183.	167/08	28	56	19	28
184.	171/08	27	56	20	28
185.	174/08	24	54	18	29
186.	177/08	27	55	18	28
187.	180/08	35	54	17	28
188.	181/08	28	55	18	28
189.	185/08	25	56	19	27
190.	232/08	29	55	20	28
191.	235/08	21	55	20	29
192.	240/08	32	55	20	28

Sl.No	P.M.No	Age	HC cm	SD mm	TD mm
193.	246/08	35	54	19	29
194.	257/08	25	56	18	28
195.	274/08	42	55	19	28
196.	276/08	48	55	19	28
197.	280/08	25	55	19	28
198.	282/08	29	55	20	28
199.	292/08	32	56	21	28
200.	295/08	40	55	18	28
201.	302/08	31	55	18	28
202.	307/08	45	55	18	28
203.	311/08	56	55	19	28
204.	321/08	50	54	18	29
205.	325/08	40	55	20	28
206.	329/08	20	54	18	28
207.	338/08	44	55	18	29
208.	341/08	59	56	19	29
209.	353/08	38	54	20	30
210.	356/08	40	54	18	29
211.	363/08	55	55	18	30
212.	371/08	36	55	18	28
213.	373/08	34	55	19	28
214.	375/08	20	54	20	28
215.	376/08	42	55	18	29
216.	379/08	18	55	18	28
217.	384/08	52	54	18	28
218.	388/08	60	55	18	28
219.	389/08	37	55	20	28
220.	390/08	36	55	18	28
221.	395/08	26	55	18	28
222.	409/08	45	55	18	28
223.	413/08	25	55	19	29
224.	422/08	18	55	18	28
225.	454/08	55	54	18	28
226.	459/08	45	55	20	28

Sl.No	P.M.No	Age	HC cm	SD mm	TD mm
227.	469/08	24	55	18	29
228.	470/08	40	56	18	28
229.	477/08	26	55	19	28
230.	479/08	21	55	19	28
231.	487/08	43	55	18	28
232.	488/08	33	54	20	27
233.	491/08	28	55	18	29
234.	492/08	18	55	18	29
235.	499/08	40	55	18	28
236.	501/08	27	54	18	29
237.	507/08	19	55	18	28
238.	547/08	39	55	19	28
239.	549/08	48	55	18	28
240.	550/08	36	55	20	28
241.	556/08	26	55	18	28
242.	591/08	40	55	18	28
243.	597/08	58	55	19	29
244.	600/08	24	55	18	28
245.	603/08	42	56	18	28
246.	605/08	26	55	18	28
247.	607/08	20	54	19	30
248.	608/08	40	55	20	29
249.	613/08	22	56	18	28
250.	627/08	53	55	18	28
251.	633/08	31	55	20	28
252.	638/08	55	56	18	29
253.	642/08	41	55	18	28
254.	669/08	34	55	18	29
255.	671/08	25	54	18	28
256.	690/08	42	55	20	30
257.	691/08	60	55	18	28
258.	697/08	54	56	19	28
259.	702/08	23	55	18	27
260.	708/08	50	55	18	28

Sl.No	P.M.No	Age	HC cm	SD mm	TD mm
261.	709/08	25	55	18	28
262.	725/08	55	55	18	28
263.	727/08	52	54	19	28
264.	729/08	33	54	18	29
265.	734/08	41	55	18	28
266.	737/08	40	55	18	28
267.	744/08	41	56	19	28
268.	746/08	50	55	19	28
269.	749/08	33	55	18	28
270.	760/08	50	54	18	28
271.	761/08	28	55	18	29
272.	740/08	21	54	19	28
273.	762/08	21	55	19	28
274.	763/08	32	55	19	28
275.	764/08	35	55	19	28
276.	765/08	28	55	18	28
277.	766/08	29	54	18	28
278.	769/08	45	55	20	28
279.	787/08	55	55	20	28
280.	788/08	20	55	18	28
281.	791/08	27	55	18	28
282.	794/08	43	54	18	28
283.	798/08	48	55	18	29
284.	803/08	46	55	18	30
285.	811/-8	59	55	19	28
286.	818/08	27	55	18	28
287.	821/08	35	55	18	28
288.	822/08	60	55	19	28
289.	824/08	30	54	18	28
290.	825/08	55	55	20	29
291.	827/08	45	56	18	28
292.	837/08	45	55	18	28
293.	839/08	45	55	18	28
294.	847/08	50	55	19	28

Sl.No	P.M.No	Age	HC cm	SD mm	TD mm
295.	849/08	38	54	21	28
296.	851/08	40	55	18	29
297.	856/08	20	55	18	28
298.	857/08	46	55	19	28
299.	862/08	19	55	18	27
300.	870/08	60	55	18	28
301.	872/08	22	55	18	27
302.	873/08	45	55	19	28
303.	874/08	49	55	18	28
304.	878/08	48	55	18	29
305.	887/08	48	55	18	28
306.	888/08	60	55	18	28
307.	889/08	60	54	19	28
308.	890/08	50	55	20	28
309.	900/08	36	55	18	28
310.	904/08	55	56	18	29
311.	905/08	59	55	18	28
312.	906/08	53	55	18	30
313.	909/08	43	54	18	28
314.	913/08	47	55	18	28
315.	918/08	58	55	18	28
316.	925/08	40	55	18	28
317.	940/08	49	55	18	29
318.	941/08	24	54	18	28
319.	942/08	30	55	18	28
320.	943/08	51	55	18	28
321.	944/08	52	55	18	28
322.	948/08	28	54	19	29
323.	972/08	44	54	19	28
324.	976/08	28	55	19	28
325.	984/08	36	55	18	28
326.	1018/08	45	55	18	28
327.	1023/08	50	55	18	28
328.	1029/08	37	55	18	28

Sl.No	P.M.No	Age	HC cm	SD mm	TD mm
329.	1036/08	36	56	18	30
330.	1044/08	22	55	20	28
331.	1065/08	47	55	18	28
332.	1068/08	45	54	18	29
333.	1069/08	50	55	18	28
334.	1080/08	45	55	19	28
335.	1082/08	50	55	18	27
336.	1094/08	25	55	18	28
337.	1097/08	28	54	18	28
338.	1104/08	38	55	18	28
339.	1110/08	60	55	18	28
340.	1111/08	36	55	18	27
341.	1112/08	20	55	18	27
342.	1138/08	55	55	18	28
343.	1141/08	41	54	18	29
344.	1148/08	29	54	18	28
345.	1152/08	42	55	18	28
346.	1155/08	30	55	19	30
347.	1157/08	53	55	18	28
348.	1159/08	44	56	18	28
349.	1162/08	52	55	18	28
350.	1168/08	46	54	18	28
351.	1161/08	42	55	18	29
352.	1171/08	38	55	19	28
353.	1226/08	32	55	20	28
354.	1240/08	46	54	18	28
355.	1246/08	35	55	18	28
356.	1248/08	35	55	18	29
357.	1267/08	35	55	18	30
358.	1268/08	33	55	18	28
359.	1272/08	41	55	18	28
360.	1281/08	48	55	18	28
361.	1294/08	50	55	19	29
362.	1297/08	43	55	18	28

Sl.No	P.M.No	Age	HC cm	SD mm	TD mm
363.	1298/08	55	55	18	28
364.	1307/08	42	54	18	28
365.	1308/08	23	55	19	27
366.	1314/08	50	54	18	28
367.	1318/08	22	55	20	29
368.	1319/08	40	56	18	28
369.	1320/08	27	55	18	30
370.	1321/08	48	55	18	28
371.	1322/08	42	55	18	28
372.	1333/08	40	55	18	28
373.	1334/08	47	55	18	28
374.	1338/08	60	55	18	28
375.	1342/08	30	54	18	28
376.	1343/08	42	55	19	28
377.	1345/08	30	55	18	28
378.	1350/08	24	55	18	28
379.	1355/08	45	55	18	28
380.	1361/08	32	55	18	28
381.	1364/08	25	55	19	27
382.	1369/08	55	55	18	28
383.	1372/08	32	54	18	28
384.	1373/08	30	55	18	29
385.	1388/08	38	55	20	28
386.	1398/08	24	55	18	28
387.	1399/08	25	54	18	29
388.	1409/08	26	55	18	28
389.	1411/08	41	54	19	28
390.	1423/08	45	55	18	28
391.	1476/08	58	55	18	28
392.	1474/08	44	55	17	28
393.	1479/08	45	55	18	28
394.	1507/08	56	55	18	28
395.	1512/08	37	55	18	29
396.	1574/08	19	55	18	28

Sl.No	P.M.No	Age	HC cm	SD mm	TD mm
397.	1576/08	54	55	18	28
398.	1585/08	60	55	18	28
399.	1602/08	46	54	18	30
400.	1648/08	25	55	18	28
401.	1664/08	40	55	18	28
402.	1670/08	27	55	19	28
403.	1674/08	60	55	18	29
404.	1700/08	37	54	18	30
405.	1701/08	21	55	18	28
406.	1719/08	26	56	20	28
407.	1756/08	56	54	18	28
408.	1757/08	25	55	18	28
409.	1761/08	53	54	19	28
410.	1770/08	35	55	18	29
411.	1787/08	26	55	18	28
412.	1790/08	60	56	18	28
413.	1813/08	45	55	18	27
414.	1814/08	20	56	18	28
415.	1860/08	24	55	18	28
416.	1923/08	45	55	18	28
417.	1924/08	38	55	19	28
418.	1925/08	38	55	20	28
419.	1926/08	48	55	17	28
420.	1928/08	29	55	18	29
	Sum	**9988**	**14273**	**4777**	**7326**
	Average	**38.41538**	**54.89615**	**18.37308**	**28.17692**
	Std Dev	**11.80196**	**0.513133**	**0.716091**	**0.627127**

HC – Head circumference;
SD – Sagittal diameter;
TD – Transverse diameter.
PM No – Postmortem number.

REFERENCES

1. K Mathiharan and Amrit K Patnaik. Modi's Medical Jurisprudence and Toxicology.Lexis Nexis Butterworths NewDelhi Twentythird edition P263-64,275

2. John G Clement and David L Ranson, Craniofacial identification in Forensic medicine Arnold press London second edition 2005. on first reprint 2006. P 53-54 P38-42

3. P.C.Dikshit. Textbook of Forensic Medicine and Toxicology, Peepee Publishers New Delhi,First edition,2007. P 66-67.

4. Forensic Anthropology Training Manual Karen Ramey Burns second edition.P 2-5

5. Montagu A. *A Handbook of Anthropometry*. Springfield, Illinois, U.S.A. Charles C. Thomas Pub Ltd, 1960.

6. Kosa F (2000). Application and role of anthropological research in the practice of forensic medicine. *Acta Biol Szeged* 2000;44 (1-4):179-188.

7. Moenssens AA. *Fingerprinting Techniques*- Inbau Law Enforcement Series, Radnor, Pennsylvania: Chilton Book Company, 1995.

8. Reichs KJ, Bass WM. *Forensic Osteology: Advances in the Identification. of Human Remains (2nd Edition)*. Springfield, Illinois, U.S.A. Charles C. Thomas Pub Ltd, 1998.

9. Adams BJ, Byrd JE. interobserver variation of selected postcranial skeletal remains.J Forensic Sci 2002;47(6):1193-1205.

10. Krogman WM. *The Human Skeleton in Forensic Medicine*. Springfield, Illinois, U.S.A. Charles C. Thomas Pub Ltd, 1962.

11. Krogman WM, Iscan YM. *The Human Skeleton in Forensic Medicine* (2nd edition) Springfield, Illinois, U.S.A. Charles C. Thomas Pub Ltd, 1986.

12. Galloway A, Simmons TL. Education in Forensic Anthropology: appraisal and outlook. *J Forensic Sci* 1997;42(5):796-801.

13. Kerley ER. Recent developments in forensic anthropology. *Yrbk Phys Anthropol* 1978;21:160-173.

14. Iscan MY. Global forensic anthropology in the 21st century (Editorial). *Forensic Sci Int* 2001;117:1-6.

15. Iscan MY. Forensic anthropology of sex and body size (Editorial). *Forensic Sci Int* 2005;147:107-112.

16. Krishan Vij. Textbook of Forensic Medicine and Toxicology,Elsevier New Delhi,Third edition 2005. P 68-69.

17. Apurba Nandy. Principles of Forensic Medicine.New central book agency Calcutta,Second edition reprint 2004. P48-49.

18. Dr K.S. Narayan Reddy. The Essentials of Fornsic Medicine and Toxicology, Twentysixth edition 2007.

19. Giles E, Elliot O. Race identification from cranial measurements. *J Forensic Sci* 1962;7:147-157.

20. Howells WW. Multivariate analysis for the identification of race from the crania. In Stewart TD (ed.), *Personal Identification in Mass Disasters,* Washington DC, National Museum of Natural History:111-122.

21. Werner U Spitz .Medicolegal Investigation of death, Charles C Thomas publishers,U.S.A. Fourth edition 2004. P210-213.

22. Patriquin ML, Steyn M and Loth SR. Metric analysis of sex differences in South African black and white pelves. *Forensic Sci Int* 2005;147(2-3):119-127. 23.Rissech C, Garcia M, Malgosa. Sex and age diagnosis by ischium morphometric analysis. *Forensic Sci Int* 2003;135(3):188-196.

24. Rissech C, Malgosa A. Ilium growth study: applicability in sex and age diagnosis. *Forensic Sci Int* 2005;147(2-3):165-174.

25. Trancho GJ, Robledo B, Lopez-Bueis I, Sanchez JA. Sexual determination of the femur using discriminant functions. Analysis of a Spanish population of known sex and age. *J Forensic Sci* 1997;42(2):181-185.

26. Asala SA. Sex determination from the head of the femur of South African whites and blacks. *Forensic Sci Int* 2001;117(1-2):15-22.

27. Purkait R. Triangle identified at the proximal end of femur: a new sex determinant. *Forensic Sci Int* 2005;147(2-3):135-139.

28. Iscan MY, Yoshino M, Kato S. Sex determination from the tibia: Standards for contemporary Japan. *J Forensic Sci* 1994;39(3):785-792.

29. Slaus M, Tomicic Z. Discriminant function sexing of fragmentary and complete tibiae from medieval Croatian sites. *Forensic Sci Int* 2005;147(2- 3):147-152.

30. Frutos LR. Determination of sex from the clavicle and scapula in a Guatemalan contemporary rural indigenous population. *Am J Forensic Med Pathol* 2002;23(3):284-288.

31. Frutos LR. Metric determination of sex from the humerus in a Guatemalan forensic sample. *Forensic Sci Int* 2005;147(2-3):153-157.

32. Kemkes-Grottenthaler A. Sex determination by discriminant analysis: an evaluation of the reliability of patella measurements. *Forensic Sci Int* 2005;147(2-3):129-133.

33. Mall G, Hubig M, Buttner A, Kuznik J, Penning R, Graw M. Sex determination and estimation of stature from the long bones of the arm. *J Forensic Sci* 2001;117:23-30.

34. Falsetti AB. Sex assessment from metacarpals of human hand. *J Forensic Sci* 1995;40(5):774-776.

35. Smith SL. Attribution of foot bones to sex and population groups. J Forensic Sci 1997;42(2):186-195.

36. Henry Gray (1821–1865). Anatomy of the Human Body 1918.

37. Gray"s Anatomy, Williams and Warwick.Churchil Livingstone 1980 P 307-312.

38. Iscan MY. A comparison of techniques on the determination of race, sex and stature from the Terry and Harmann-Todd collections. In Gill GW, Rhine JS (Eds.) Skeletal Attribution of Race: Methods for Forensic Anthropology. Maxwell Museum of Anthropology, Paper No. 4, University of New Mexico, Albuquerque, NM, 1990, Pp. 73-81.

39. Hecht TJ, Horton WA, Reid CS, et al. Growth of the foramen magnum in achondroplasia. American journal of Medical Genetics 32:528-35, 1989.

40. Reich JB, Sierra J, Camp W,et al. Magnetic resonance imaging measurements and clinical changes accompanying transtentorial and foramen magnum brain herniation. Annals of Neurology 33: 159-7-, 1993.

41. Ropper AH. MRI demonstration of the major features of herniation. J Neurol Neurosurg Psychiatry 56: 932-5, 1993.

42. George B, Lot G, Boissonnet H. Meningioma of the foramen magnum: A series of 40 cases. Surg Neurol 47: 371-9, 1997.

43. Salas E. Sekhar LN, Ziyal IM, et al. Variations of the extreme lateral craniocervical approach: Anatomical study and clinical analysis of 69 patients. J neurosurg 90: 206-19, 1999.

44. Spektor S, Anderson GJ, McMenmey SQ, et al. Quantitative description of the far-lateral transcondylar transtubercular approach to the foramen magnum and clivus. J Neurosurg 92: 824-31, 2000.

45. Wanebo JE, Chicoine MR. Quantitative analysis of the transcondylar approach to the foramen magnum. Neurosurgery 49: 934-41, 2001.

46. Catalina-Herrera CJ. Study of the anatomic metric values of the foramen magnum and its relation to the sex. Acta Anat 130: 344-7, 1987.

47. Munuz M. Consideraciones anatomo-radiologicas sobre el estudio metrico de la base del craneo; Minor thesis, Universidad de sevilla 1983.

48. Schmeltzer A, Babin E, Wenger JJ. Measurement of the foramen magnum in children and adults. Neuroradiology213: 162-3 1971.

49. Wackenheim A. Roentgen diagnosis of the craniovertebral region. Springer,New York 1974.

50. Zaragoza E. Malformaciones de la charnela occipito-cervical y sus correlaciones clinicas. Ministerio del Trabajo, IN de Prevision. Madrid 1974.

51. Rouviere H. Anatomia humana descriptive y topografica. Bailly Bailliere, Madrid 1956.

52. Testut L, Latarjet A. Tratado de Anatomia humana Salvat, Barcelona 1977.

53. Muthukumar N.Swaminathan Acta Neuro(wien) Madurai Tamilnadu 2005;147:889-95.

54. Bernard Knight.Knights Forensic Pathology Arnold London.Third edition2004. P22-23

55. J URGEN Ludwig, Handbook of Auutopsy Practice Humana press Newjersy 2002 P65-69.

56. Human Bone Manual Tim. D. White, Pieter.A. Folkens 2005.

57. Fischgold H. Wackenheim A. La radiographie des formations intrarachidiennes. Masson, Paris, 1965.

58. K.A. Murshed Turk J Med Ssi 33(2003) 301-306.

59. Zaidi SH, Dayal SS. Variations in the shape of foramen magnum in Indian skulls. Anat Anz Jena 167:338-40 1988.

60. Sindel M, Ozkan O, Ucar Y, et al. Foramen magnum anatomic varyasyonlari. Akd.O. Tip Fak DERGISI6; 97-102, 1989.

INSTITUTIONAL ETHICAL COMMITTEE

GOVERNMENT GENERAL HOSPITAL & MADRAS MEDICAL COLLEGE,
CHENNAI-600 003.

Telephone: 044-2530 5000
Fax : 044 – 25305113

K.Dis.No.16328 P & D3/Ethics/Dean/GGH/08 Dated: 3.9.2008

Title of the work : "Size of formamen magnum and its relation To sex"

Principal Investigator : Dr-T. Vedanayagam.

Department : Institute of forensic Medicine. MMC, ch.3.

The request for an approval from the Institutional Ethical Committee (IEC) was considered on the IEC meeting held on 10th September 2008 at 2 P.M in Government General Hospital, Deans, Chamber, Chennai-3.

The members of the Committee, the Secretary and the Chairman are pleased to approve the proposed work mentioned above, submitted by the principal investigator.

The principal investigator and their term are directed to adhere the guidelines given below:

1. You should get detailed informed consent from the patients/participants and maintain confidentiality.
2. You should carry out the work without detrimental to regular activities as well as without extra expenditure to the Institution or Government.
3. You should inform the IEC in case of any change of study procedure, site and investigation or guide.
4. You should not deviate form the area of the work for which I applied for ethical clearance
5. You should inform the IEC immediately, in case of any adverse events or serious adverse reactions.
6. You should abide to the rules and regulations of the institution(s)
7. You should complete the work within the specific period and if any extension of time is required, you should apply for permission again and do the work.
8. You should submit the summary of the work to the ethical committee on completion of the work.
9. You should not claim funds from the Institution while doing the work or on completion.
10. You should understand that the members of IEC have the right to monitor the work with prior intimation.

SECRETARY	CHAIRMAN	DEAN
IEC, GGH,CHENNAI	IEC, GGH,CHENNAI	GGH &MMC, CHENNAI

Rkm.5.9(2)